'COMPARATIVE PERFORMANCE OF TWO VARIETIES OF MAIZE UNDER SINGLE VERSUS SPLIT APPLICATION OF DIFFERENT LEVELS OF NITROGEN'

By

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THESIS

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I HEREBY RECOMMEND THAT THE THESIS PREPARED UNDER MY SUPERVISION BY SHRI BRAJ VALLABH CHAND BHANDARI ENTITLED 'COMPARATIVE PERFORMANCE OF TWO VARIETIES OF MAIZE UNDER SINGLE VERSUS SPILIT APPLICATION OF DIFFERENT LEVELS OF NITROGEN' BE ACCEPTED IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE IN AGRICULTURE (AGRONOMY).

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I N T R O D U C T I O N.

UDAIPUR region accounts for nearly 70 per cent of acreage and production of maize in Rajasthan. But the production rate per acre of maize is far from satisfactory. Very high yields in some other parts of the country and abroad are indicative of great potential with which the crop is endowed and point to some lacuna in our technique of maize cultivation. Since, maize is one of the most important crops of the State, any improvement in the yield of maize will go a long way to improve the lot of millions of poverty striken people.

One of the attempts towards perfecting the technique of maize culture is to select a suitable variety. Because maize is grown in rotation with wheat selection of a variety, which is early to mature, gives fairly good yields and leaves sufficient time for the preparation of field for the succeeding crop, will be of considerable economic importance.

Maize is generally raised with the onset of the monsoon and erratic performance of the crop has sometimes been attributed to the bad fertilizer management. Because the nitrogen requirement of the crop is very high a single application of nitrogenous fertilizers is beset with problems of leaching, poor germination, forced growth and the danger of drought. Russell (1950) reported that the amount of nitrogen and its time of application have a strong bearing upon the growth, yield, quality and maturity of the crop. This will appear to be a common observation that if the nutrient requirement of the crop is spread over a longer span of time, split application might prove a safeguard against the hazards of leaching and wasteful use of fertilisers.

Maize crop responds remarkably to nitrogenous fertilizers and as such application of various doses have been recommended by various workers. Since, efficiency in the use of a particular dose may be increased or decreased by the time of application, selection of a variety and working out the best dose of nitrogen in relation to time of application merit greater attention of the present day agronomists in this region.

Thus, one of the ways to arrive at a definite manuring programme of maize in any one locality would be to experiment and test different varieties of maize under various levels and times of application of nitrogenous fertilizers. In the light of these considerations a field experiment, entitled 'Comparative performance of two varieties of maize under single versus split application of different levels of nitrogen', was planned out at the Agronomy Farm of the Rajasthan College of Agriculture, Udaipur; in the _Kharif_ (rainy) season of 1962-'63. The present thesis embodies the results of the investigation.

LITERATURE REVIEWED

MAIZE has been used as a test plant to diagnose nutrient deficiency symptoms and nitrogen alone been found to be important element in the nutrition of maize. Unfortunately the widespread deficiency of nitrogen in most of the maize growing areas, limits the production of maize. A brief review of work done in India and in foreign countries regarding amount and time of application of nitrogen to different varieties of maize is given in this chapter.

1. RESPONSE OF MAIZE VARIETIES TO LEVELS AND TIME OF APPLICATION OF NITROGEN:-

Smith (1934), with nutrient solutions and Lynes (1936), with sand culture, while studying the behaviour of a large number of inbred lines and hybrids to varying concentrations of nitrogen found less differential responses among the various corns. Kurtz et al. (1949) while comparing two single crosses found that one hybrid yielded poorly under low levels of nitrogen, but under adequate nitrogen both yielded equally well. Miller et al. (1950) reported that Mexican corns are capable of giving some yield under more adverse soil fertility conditions than the American, the later would become barren under low nutrient conditions. Fertilizer response data obtained would indicate that the Mexican corns are not capable of utilizing high levels of available nutrients.

Calma and Castro (1950) reported that ammonium sulphate, applied to flint maize variety Native Yellow

@ 100 kg./hect. at sowing time, either in dry or the wet season, did not affect the germination, flowering or the ripening dates. Except on badly drained soils, the maize plants of the fertilized plots were generally of a darker green colour and were more vigorous than the non-fertilised control plant.

Bhatnagar (1957) reported the results of yield trials conducted at the Maize Breeding Station, Udaipur for three years. Varieties like Malan and Bassi selected gave higher yields over local and variety Malan yielded higher than variety Bassi selected. But the former took 105 days to mature where as the latter took only 85 days to mature.

Lanza (1957) on the basis of plot trials conducted in 1956 reported that the yield of a hybrid maize of the Wisconsin 641 AA type is dependent on the amount of nitrogen applied irrespective of the type of nitrogenous fertilizer used and the date of its application. Yield varied from 4,600 kg./hect. with no nitrogen applied to 7,200 kg./hect. with the application of 100 kg. of nitrogen per hect. Lanza (1958) while investigating the chemical manuring of maize using 3 hybrids of different vegetative cycles observed no differences in yields due to increasing amounts, type and time of application of nitrogenous fertilizer or due to the maturity class of hybrid varieties.

Chela (1958) with local yellow flint type obtained high yield with nitrogen applied from the source of either ammonium sulphate or ammonium phosphate. Strang and Broue (1959) reported that G.H. 128 hybrid maize with the application of 2 cwt. ammonium sulphate per acre at tasseling resulted in a higher grain percentage (1.44) and grain yield (85.9 bu./acre) than other treatments. Pronin and Afanašev (1960) showed that the nutrients supplied at 4th leaf stage produced the best grain yield of maize variety Voronezskaja 76 (3,560 kg./hect., average of 2 years).

Yawalkar et al. (1962) indicated that hybrid maize Ranjit utilized about 130 lb. N, 50 lb. P, 110 lb. K, 37 lb.Ca, 33 lb. Mg and 22 lb. S to produce 60 mds. or more grains.

Giffard (1955) reported the effect of 0,300 and 600 lb. of nitrate of soda per acre on protein and mineral contents of grain of maize varieties 50H35 (hybrid) and Hickory King (selected). From two seasons' results there appeared to be a tendency for maize to take up certain nutrients, apart from nitrogen, in greater quantities when top-dressed fairly heavily with nitrogen. 50H35 out-yielded Hickory King at all levels of nitrogen and the highest level favoured the highest protein content. From IARI, it was reported (1962) that nitrogen applications significantly increased the protein content of grain of hybrid maize, US 578; under medium fertility conditions 135 kg./hect. was found to be optimum for this variety.

2. GROWTH AND YIELD OF MAIZE AS AFFECTED BY THE LEVELS OF NITROGEN.

(a) Growth:- Nitrogen, being an important constituent of protoplasm, when applied imparts luxurient vegetative growth, increases height of the plant and number of leaves. It also makes the crop more succulent and susceptible to lodging (Miller, 1931). Graucinin (1932) found a direct relation between the growth of aerial organs and the amount of nitrogen. Russell and Watson (1940) reported a considerable increase in the total dry matter content of cereals with the application of nitrogenous fertilizers. Jordan et al. (1950) observed that dry matter elaboration approached linearity when large amounts of nitrogenous fertilizers were applied. Tondon and Varshney (1954) obtained higher yields of green maize fodder with 60 lb. nitrogen per acre.

Crowther et al. (1937) from their experiments with maize in Nile delta reported that high nitrogen application hastened the time of flowering and maturity and increased the grain yield relative to straw. Rai (1961) reported that nitrogen applied at the time of sowing accelerated early vegetative growth and application of 88 lb. of nitrogen per feddan hastened tasseling, silking and maturity by 9 to 16 days. David et al. (1961) reported increase in number of cobs, 1,000 kernel weight and average number of grains per cob with the application of nitrogen.

(b) Yield:- With the application of different levels of nitrogen significant increases in grain yield were observed by a number of workers. To be more specific a brief mention of the results obtained by few of them would be desirable. Significantly higher yields of maize grain were obtained by Sen and Kavitkar (1956) with 40 lb. nitrogen per acre; Datta et al. (1957) with 40 lb. and 80 lb. nitrogen per acre (yield increased by 7.94 and 11.86 mds. per acre respectively); Verma and Sharma (1958) with 20, 40 and 60 lb. nitrogen per acre; Reichman et al. (1959) and Anderson and MacGregor (1960) with 80 lb. nitrogen per acre.

Highest yields of maize grain have been recorded by Zuber et al. (1954) with 120 lb. nitrogen per acre (100 bushels); Dois (1954) with 165 kg. per hectare; Huntun and Yungen (1955) with 160 lb. nitrogen per acre and Nandpuri (1960) with 180 lb. nitrogen per acre.

Nelson (1956) indicated that yield responses to increasing increments of nitrogen usually, followed the Mitscherlich type curve, provided the levels of other nutrients and moisture are not limiting. Goor (1957) reported that application of nitrogen upto 300 kg. of ammonium sulphate per hectare increased maize grain yield and gave about 4,000 kg. per hectare but higher rates of application gave diminishing returns. Fulton and Findlay (1960) also corroborated the same observation by reporting that application of 40 lb. nitrogen per acre produced a marked increase in yield of maize grains, but rate of increase diminished with the further nitrogen increments.

Thakur et al. (1956) reported that application of maximum, i.e. 100 lb. nitrogen per acre, was found to be quite economical. Raheja et al. (1957) when considered the economics of fertilisation indicated that higher nitrogen applications upto 60 lb. per acre to maize would definitely increase the margin of profits over the initial dose of 20 lb. Relwani (1962) went on to say that fertilisers like ammonium sulphate proved quite economical even with such adverse price structure as Rs. 10,00 per maund of maize and Rs. 0.95 per pound of nitrogen (i.e. Rs. 425.00 per ton of ammonium sulphate).

3. GROWTH AND YIELD OF MAIZE AS AFFECTED BY THE TIME OF APPLICATION OF NITROGEN

(a) Growth:- Subies (1956) reported that the critical period in the nitrogen nutrition of maize, particularly in dry season is just prior to flowering. Sahay (1957) observed that maize plants on one acre required 3 to 5 lb. of nitrogen in the first month. During July and August when the crop is making it's rank growth and setting ears it may require as much as 3 to 5 lb. of nitrogen per day. Besides early growth stimulation nitrogen is needed by the maize plant through out the growing period but it is used in greatest quantity during the grand growth period, about 2 weeks before and 2 weeks after tasseling.

As reviewed by Nelson (1956) application of fertilizer at sowing time results a marked increase in the growth of young corn plants and gives several beneficial effects. Better weed control is possible, in as much as taller corn is easier to cultivate and competes with weeds. Size of the root system of young plants is increased more rapidly, thus increasing the absorptive zone. Silking may be hastened from 2 to 10 days, and the time required for maturing the crop reduced correspondingly. (Troug et al., 1925; Smith and Harper, 1926; Gerdel, 1931; Olsen and Walster, 1934; Dumenil and Show, 1952; Krantz and Chandler, 1954). MacGregor (1954) noted some delay in maturity from nitrogen side dressings. Young et al. (1960) found that corn maturity was not delayed by nitrogen fertilization @ either 0.40 or 80 lb. of nitrogen applied as top-dressing and @ either 0.30 and 60 lb. of nitrogen per acre applied at sowing as judged by the moisture content of grains at maturity of the crop.

(b) Yield:- Gudkova (1939) in pot experiments found that fractional application of nitrogen applied at three times, was most effective and increased yields to the extent of 73 percent. Further, it was observed by him that fractional applications of nitrogen were found to be more effective on low soil moisture contents.

Raheja (1956) recommended that half of the dose of nitrogen (40 to 60 lb. per acre) should be applied at sowing and the remaining half four weeks after sowing to get higher yields of maize. Corby (1957) reported that the bulk of the nitrogen dressing should be applied about five weeks after sowing with small proportions at sowing and at tasseling, to obtain higher yield responses. Vasiliu and Davidescu (1959) reported that the best timesto apply nitrogen to irrigated maize were during the tillage before sowing, when the third leaf appeared and when the male inflorescence appeared.

Goor (1953) obtained highest grain yields when application of ammonium sulphate was in two equal dressings which were applied at 0 to 3 weeks after sowing and again at 3 to 8 weeks after sowing. Cervato (1959) recorded highest yield of 9,035 kg. of grain (15.5% moisture) per hectare by applying 60 kg. of nitrogen per hectare, half of the ammonium nitrate being applied at sowing and half as a top-dressing. Tattersfield (1959) found that yields were increased by the application of 300 to 500 lb. of ammonium sulphate per acre as top-dressing, through applying more than 300 lb. per acre as top-dressing resulted in a little further increase.

On the contrary some of the workers could not find out any beneficial effect of split application of nitrogen in terms of yield of maize grain. Kristriansson (1941) concluded that nitrogen top-dressing (with ammonium nitrate) had little effect on grain and straw yield, when applied at the time of ear-emergence. He further mentioned that nitrogen top-dressing should only be applied to a well developed crop, otherwise yields would go down. Lanza (1959) from a series of experiments concluded that grain yields were generally not affected by the time of application of nitrogen (either at sowing or as top-dressing) provided it was applied before the formation of 15th leaf. Yields were reduced if the nitrogen was applied later than this. Department of Agriculture, Nyasaland (1959), reported that ammonium sulphate @ 100 or 200 lb. per acre was applied at sowing, at 30 days after sowing, or at first tassel emergence, in either single or split dressings. Time of application had no significant effect on yield. Arnon (1962) reported that during three growing seasons ammonium sulphate gave substantial and consistent yield increases but the split applications of nitrogen were not better than a single application before sowing. Latkovics (1962) observed that top-dressing with nitrogen at the time of thinning and tasseling had no significant effect on the yield of maize.

4. QUALITY OF GRAIN AS AFFECTED BY THE LEVELS AND TIME OF APPLICATION OF NITROGEN.

Miller (1938) mentioned that protein content of grain increases with the application of nitrogenous fertilizers, even when the effect of fertilizer on yield becomes negligible. Selke (1938) reported that late application of nitrogen when used as supplements to normal nitrogen fertilization, increased the protein contents of cereals. Russell and Watson (1939), in an experiment, found that only late top-dressing (after flowering) caused a significant increase in the nitrogen content of the grain. Kristianson (1941) obtained an increase in the crude protein content with the application of nitrogenous fertilizer at flowering. A review, given by Terlikowski (1947), showed that under certain conditions of nitrogen fertilization to cereals at the time of flowering led to appreciable increases in the percentage of nitrogen in the ripe grain. Such late applications achieved this increase only if the soil moisture conditions were satisfactory, or when rain immediately preceded or followed the application of nitrogen.

A number of workers have reported an increasing tendency in the mean protein contents in grains with the increasing levels of nitrogen. Wessels and Pretorius (1953) observed that application of high nitrogen gave high protein content but the phosphate and calcium contents of the grain were not affected significantly. Prince (1954) reported that increasing rate of nitrogen treatment from 15 to 135 lb. per acre increased the crude protein contents in grains from 7.81 to 9.53 per cent. Zuber et al. (1954) concluded that nitrogenous and phosphatic fertilisers have often been reported to increase the protein and phosphorus content in maize grains but their effect on other constituents were not uniform. Hunten and Yungen (1955) recorded a consistant increase in the percentage of protein in grain with increase in nitrogen application. Per cent protein with 0, 100, 200 and 320 lb. nitrogen per acre were 6.92, 8.06, 9.30 and 9.58 respectively.

Galvez et al.(1956) reported that nitrogen content of grain increased with increasing application upto 135 kg. per hectare nitrogen as ammonium sulphate. There was an inconsistant correlation between phosphorus in the grain and nitrogen applied. Lang et al. (1956) obtained decreased crude protein contents of grain with decrease in nitrogen levels. Thomas (1959) noticed that when nitrogen application increased from 120 to 240 lb. per acre it caused an increase in the percentage of protein content in maize grains. Fulton and Findlay (1960) concluded that nitrogen fertilizer was the only one affecting the nitrogen composition of grain. The increase in nitrogen content of the ear shoot leaf amount to 60 per cent and of the grain 25 per cent. Nandpuri (1960) observed that application of nitrogen at higher rates increased the protein content of grain. Gupta (1961) concluded that the contents of nitrogen (N) and phosphate (P_2O_5) in in the grain declined under intense cultivation of maize from

1954 to 1959 despite the application of FYM and /or chemical fertilizers. A lower grain nitrogen content was found in wet years than in dry years.

EXPERIMENTAL PROCEDURE

A FIELD experiment was conducted during the *Kharif* season of 1962-63 with the object of studying 'Comparative performance of two varieties of maize under single versus split application of varying levels of nitrogen'. In this chapter details of materials used and techniques followed, during the course of present investigation, are described here under.

A. EXPERIMENTAL SITE.

Udaipur is located at about a latitude of 24° North and longitude of 75° East with an elevation of 580 metres above M.S.L. It is situated in the southern part of Rajasthan and in midst of the Aravali ranges. It enjoys a typical sub-tropical climate, and has got mild winters and summers. Average annual rainfall ranges from 760 to 880 mm. most of which is distributed during a period of ranging from last week of June to last week of September. Relative humidity ranges between 75 to 95 per-cent during this period.

It was deemed necessary to present the pattern of distribution of rainfall, and maximum and minimum temperatures (Fig. 4) of this place because they influence the growth and development of a crop. Before presenting results of the experiment a concise statement about march of the crop in relation to important climatic variable has been given in the chapter on 'Experimental Results'.

<u>Soils of experimental field:</u>- The present experiment was laid out in Plot No. A(3) of the Agronomy Farm. After selecting the field and before sowing and application of fertilisers, a number of soil samples were taken from different blocks of the experimental field from a depth of 0 to 20 cms. Soils from these samples were dried, processed and mixed together. A composite sample, thus prepared, was analysed only for those characters, which are considered important from the stand point of crop production. Results of various mechanical and chemical analyses are given in Table 1.

<u>Table 1</u> - Mechanical and chemical composition of soil:

Mechanical		Chemical	
Components	Per cent	Constituents	Per cent
Coarse sand	13.50	Total nitrogen	0.0686
Fine sand	31.70	Available Phosphate	0.0015
Silt	13.65	Available Potash	0.0074
Clay	31.58	Water soluble calcium & magnesium	15.57 me./l.
Ca CO_3	5.00	Organic carbon	0.850
Water saturation	37.7	C:N ratio	12.5:1
Pore space	46.02	Cation Exchange capacity	
Specific gravity	2.15	Electrical conductance	0.95
Apparent density	1.36	pH	8.5

Results, obtained from mechanical analysis, revealed that the soil belonged to the sandy clay loam textural class. Single value soil constants indicated that the soil was heavy in nature, moderately high in moisture holding capacity and dark brown in colour. The soil puddled on being wetted and cracked profoundly on drying. This, management of the soil presented a serious problem.

A perusal of results of chemical analysis indicated that soil was poorly supplied with total nitrogen and available phosphate but was moderately supplied with available potash. Organic carbon content and consequently the C:N ratio were also low. Higher values for water soluble calcium plus magnesium and that of pH seemed to be probably due to calcareous and alkaline nature of the soil. Concentrations of salts appeared to be harmless. Thus, an over all interpretation of results obtained from chemical analyses of the soil sample amounted to the conclusion that the soil was of average fertility.

Mechanical analysis:

The mechanical analysis of the soil was done by the International method, dispersion by sodium hydroxide and hydroperoxide and sampling through Pipette method (Wright, 1939). Specific gravity, apparent density and pore space were determined by methods mentioned by Knowles and Watkins (1950).

Chemical analysis:

Nitrogen: Total nitrogen content in the soil was determined by the modified Kjeldahl's method as recommended by Bremner (1960). The digestion was done with the help of concentrated sulphuric acid and potassium sulphate was added to raise the boiling point and was used in the ratio of 1:3 with sulphuric acid.

Available phosphate: It was determined by the Olson and Bray's method. Available phosphates were extracted with Olson's reagent and thereafter the technique recommended by Dickman and Bray for colorimetric determination of the phosphate using Kletts Summerson Photoelectric Colorimeter was followed.

Available potassium: It's estimation was done through flame photometer in the saturated soil extract.

Water soluble calcium plus magnesium: It was determined by following the Versenate titration method using Eriochrome Black T as an indicator and sodium cyanide to avoid the interference and for chelating; titration was done in the flourisent light. It is mentioned in the method 7 of the USDA, Hand-Book, No. 60.

Organic carbon: It was determined by the modified Walkley's method as mentioned under method 24 of the USDA, Hand-Book, No. 60. Oxidation of the soil was done with potassium dichromate and sulphuric acid containing silver sulphate. Excess of the dichromate was titrated against ferrous sulphate using Ferroin indicator.

C:N Ratio: It was obtained by dividing organic carbon by total nitrogen content of the soil.

Cation Exchange Capacity (C.E.C.): It was estimated by Schoonover's Gypsum requirement Test, in which all the cations are displaced by normal barium chloride solution and then making the Gypsum requirement test.

Electrical conductance (E.C.): It was determined in saturated soil extract, using Solu-Bridge soil tester.

Soil reaction (pH): It was determined in a soil suspension by the Glass-electrode method, using Beckman pH meter, Model H-2.

B. DESIGN OF THE EXPERIMENT.

The present field experiment was laid out in the Randomised Block Design. Various treatments, tried in this investigation, comprised of 2 varieties of maize; 4 levels of nitrogen and 2 times of application of nitrogen making thereby 16 combinations of treatments, which were replicated 3 times. Net size of the experimental plot was 8.54 m. X 4.88 m. (28' x 16'). All around the net plot a 0.61 m.(2') wide plot border was kept. Total experimental area was 74.42 m. X 40.87m.= 0.30415 hectare (= 244' x 134' or 0.7506 acre, respectively). The plan of lay out with necessary details is given in Fig. 1. Details of the treatment and the symbols used to depict them are given below:

Varieties of maize:

V_M = Malan,

V_B = Bassi selected.

Levels of nitrogen:

N_0 = 0 kg. nitrogen per hectare (0 lb. nitrogen per acre),

N_{30} = 33.63 kg. nitrogen per hectare (30 lb. nitrogen per acre),

N_{60} = 67.26 kg. nitrogen per hectare (60 lb. nitrogen per acre),

N_{90} = 100.89 kg. nitrogen per hectare (90 lb. nitrogen per acre).

Time of application of nitrogen:

T_1 = One single dose applied at the time of sowing,

T_2 = Two split doses applied half at the time of sowing and other half at the time of tasseling.

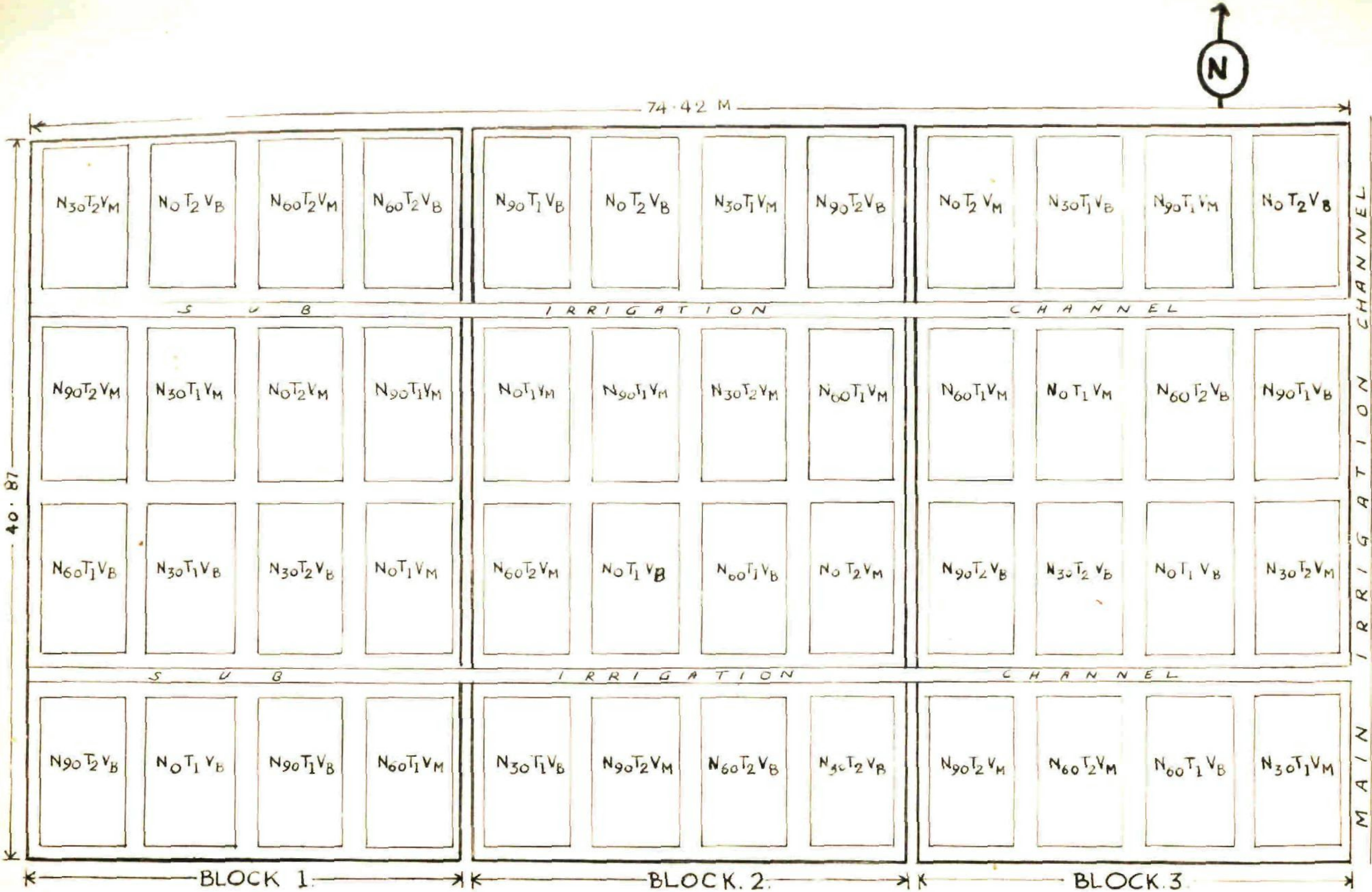

FIG. 1. PLAN OF LAYOUT

NET PLOT SIZE : 8·54 m. X 4·88 m.
GROSS PLOT SIZE : 9·76 m. X 6·10 m.

SCALE : 1 c.m. = 3·05 M.

C. FIELD OPERATIONS.

I. Pre-sowing operations:

1. Field Preparation: The experimental crop was preceded by wheat in the Rabi season. After the harvest of wheat crop one hot weather ploughing was given to the field. The field received one pre-sowing irrigation on June 26, because monsoon did not set in till that time. Under proper soil-moisture conditions the field was ploughed, harrowed and planked several times to obtain a fine, mellow and friable seed-bed. Then the plots, irrigation channels, etc. were demarkated in the field.

2. Fertilization: In order to give more congenial conditions for the performance of maize varieties under different levels and times of application of nitrogen a basal dressing of single super phosphate (16% P_2O_5) and sulphate of potash (48% K_2O) was given at the time of sowing to supply 66.26 kg. P_2O_5 per hect. (60 lb. P_2O_5 per acre) and 66.26 kg. K_2O per hect. (60 lb. K_2O per acre) respectively.

As per requirements of different plots under different treatments of nitrogen and their time of application, amount of ammonium sulphate (20% N) was calculated for each plot, weighed separately and applied broadcast in the plots. In plots, receiving treatment combinations like $N_{30}T_1$, $N_{60}T_1$ and $N_{90}T_1$, with both the varieties of maize, all the amount of nitrogenous fertilizer was applied at the time of sowing, whereas in plots receiving the other set of treatment combinations like $N_{30}T_2$, $N_{60}T_2$ and $N_{90}T_2$ half of the total amount of required fertilizer was applied at the time of sowing and the remaining half was top-dressed before the time of tasseling.

3. Seed and Sowing: Because varieties of maize formed one of the important treatments in this experiment, seeds of varieties Malan and Bassi selected (both are open pollinated, Bhatnagar, 1957) were taken and analysed for their real value, which was found to be 86.66 per cent in the former and 92.33 per cent in the latter. Seeding rates were adjusted on the basis of their real values. 2 to 3 seeds per hill were dibbled at a depth of 4 to 8 cms. on July 3, 1962. 60 cms. inter-row and 30 cms. intra-row spacings were followed to obtain 10 rows per gross plot but 8 rows per net plot.

II. Post-sowing operations:

1. Gap filling and thinning: Although real value of the seeds was quite satisfactory and moisture conditions of soil were conducive for good germination but due to picking of maize kernels from the hills by pegions, germination was patchy. In order to maintain uniformity in the stand of the crop gap filling was done. Subsequently extra seedlings were removed, leaving only one healthy plant at each hill.

2. Weeding and hoeing: Because of inadequate rainfall in the beginning weeds assumed a rank growth over the crop plants. Crop growth appeared to be suppressed firstly for want of moisture and secondly because of profuse growth

of weeds. Thus, in order to reduce competition between the crop plants and the weeds for nutrients, moisture and light 3 weedings were done at 20, 32 and 43 days after sowing.

Two hoeings were done in the field, first at 20 days after sowing with a 'Wah-wah' cultivator and the second at 43 days after sowing with a hand hoe.

3. Plant protection: In the first week of August crop was infested with the maize borers (*Chilo Zonellus* Swinh. and *Sesamia inferens* Wlk.). According to Kushwaha *et al.* (1961) the crop was once sprayed (on August 4) with "Endrin 20" EC. in the form of 0.02% emulsion spray, which proved quite satisfactory in controlling the borers. In order to put a check to the attack of army worm (*Cirphis unipunta* Haw.) dusting with 5% BHC dust @ 20 kg./hect. was done on August 10.

4. Irrigation: Due to inadequate rainfall in the latter part of July, it became necessary to irrigate the crop in order to restore vigour of the plants. Hence, the crop was irrigated on August 7 and 8.

5. Top-dressing : In accordance with the object of the experiment, second dose of nitrogen was top-dressed on August 18 (i.e. 43 days after sowing) when the crop plants were nearing tasseling. According to the treatments combinations required amount of fertilizer was applied at the base of the plants and also in between the rows. A light hoeing was given with a hand hoe in order to mix the fertilizer in the soil.

6. Harvesting and shelling: Before actual harvesting of the produce from the net experimental plot, crop plants from 60 cms. wide plot borders were harvested and removed. When most of the functional leaves became dead, spathe of the cob turned yellow and became papery and when the grainsbecame glazed and hard, harvesting was done by picking up the cobs. Cobs from the five pilot plants were picked up and put separately in bags with proper lables. Cobs from the net plot were picked up and kept separately in gunny bags and labled properly. Produce of the experimental plots was kept on the roof of a building for sun drying. The plants are cut near the ground, tied and kept in the same plot for sun drying. After 4 days of sun drying stover yield in kg./plot was recorded. After thorough drying cobs were weighed and shelled by manual labour. Yield of grains per plot, thus, obtained was recorded.

Due to difference in their period of maturity, both the varieties were harvested on different dates, the schedule followed for harvesting is given in Table IX.

D. TREATMENT EVALUATION.

I. Pre-harvest studies:

1. Growth and developmental characters: In order to probe into the mechanism of growth and incident development of the plant it was deemed necessary to study the behaviour of the developing plant under the influence of different treatments. Towards this end 5 plants were selected at random(Panse and Sukhatme, 1961) and tagged

properly, hereinafter called as '5-Pilot plants'. These plants were not disturbed till they were finally removed from the field at harvest. These plants were used for the following observations:

(i) Height per plant in cms. Height of the plant was taken from ground level upto the base of the top most fully opened leaf in the early stages of growth and from ground level to the base of tassel in later stages. Observations for height of the plant were recorded at 21, 35, 42, 49, 54 and 63 days after sowing.

(ii) Dry matter production per plant in gms. : Samples for dry matter determination were collected from the net plot excluding the pilot plants. These samples (consisting of 2 plants per plot at all stages except at 21 days after sowing when 5 plants per plot) were collected at an interval of 21 days and were continued till harvest. These samples were first of all dried in the sun, then weighed, chopped and kept in perforated paper bags in electric oven operated at 105^{o} C till constant weight. In the beginning because of the less growth whole sample was retained but later on a 100 gm. homogeneous sample was retained from the bulk.

(iii) Nitrogen content of plant material: The determination of nitrogen content in the growing plant was carried on and the samples for this study were derived from those used for dry matter determination and corresponded with the stage of dry matter determination.

The estimation of nitrogen, in the

growing plant, was done through Nesseler's method of determining ammonia or nitrogen. The digestion of 100 mgm. sample was done with the help of concentrated sulphuric acid and black colour was removed by 30 per cent hydrogen per-oxide. This acid digest was made to volume (100 ml.) and a suitable aliquot (5 ml.) was taken to which (1 ml. of 10%) sodium silicate solution was added to prevent turbidity and (2 ml. of 2.5N) sodium hydroxide was added and made to volume (50 ml.). Colour was developed with the help of Nessler's reagent applied @ 4 drops per 5 ml. of aliquot. The intensity of developed colour was read out with the help of Kletts Summerson Photoelectric- Colorimeter using filter No. 54. The transmitance reading was recorded for each sample.

A standard solution of known strength was prepared by using A.R., B.D.H. ammonium sulphate. Samples from this were taken and processed in the same manner as was done with the acid digest, but no digestion was done. From the transmitance readings, thus obtained, a calibration curve was prepared (Fig. 2) and percentage of nitrogen in the sample was plotted against transmitance reading. Then the percentage of nitrogen in the sample was read out from this curve using the following formula:

$$\% \text{ Nitrogen} = \text{Transmitance reading for a sample} \times \text{gm. of N/degree of transmitance} \times 100 \times 20 \times 10$$

II. Post-harvest studies:

2. Characters of yield and it's attributes:

Before actual harvesting of the net experimental plot, cobs were picked up from the 5- Pilot plants, tagged and kept separately. Cobs from all the plants of both varieties were not ready for harvesting thus they were picked up more than once, and number of cobs obtained from a plot in each picking was recorded. After a thorough sun drying cobs were weighed, shelled and weight of clean grains recorded. Various attributes of yield studied in this experiment include:

(i) Grain yield per hectare in quintals,

(ii) Stover yield per hectare in quintals,

(iii) Grain yield per plant in gms.,

(iv) Number of cobs per plot in first picking,

(v) Number of cobs per plot in second picking,

(vi) Total number of cobs per plot,

(vii) Number of cobs per plant,

(viii) Weight of cobs per plot in kgs.,

(ix) Weight of grains per cob in gms.,

(x) Weight of 1,000 kernels in gms. (Test-weight),

(xi) Final crop stand per plot.

3. Nutrient content of grains:

Grain samples from different plots were subjected to chemical analysis for their quality evaluation. Attributes of grain quality studied in the present experiment are:

(i) Crude protein content (%),

(ii) True protein content (%),

(iii) Phosphorus content (%),

(iv) Potassium content (%) and

(v) Calcium content (%)

These determinations were done with the object to know the effect of various treatments on quality of grains.

(i) Crude protein: Per cent nitrogen in grain samples obtained, by following the same method mentioned for determination of nitrogen content in plant material (page No. 23), was multiplied by 6.25 to get crude protein content (%) in grain.

(ii) True protein: The true protein in grain samples was determined by precipitating it with Stutzer's reagent. Precipitates were filtered and then analysed for nitrogen content through Kjeldahl's method (Knowles and Watkins, 1947). Per cent nitrogen thus obtained was also multiplied by 6.25 to get true protein content (%) in grain.

(iii) Phosphorus: Determination of phosphorus in grain was done (by method No. 61 as given USDA, Hand-Book No. 60) in the acid digest prepared by the use of contentrated nitric acid and 72% perchloric acid. The acid digest was made to volume and 5 ml. aliquot was taken to which 5 ml. each of ammonium vandate and ammonium molybdate were added to develop the colour. The intensity of the developed colour was noted with the help of Kletts Summerson Photoelectric Colorimeter using filter No. 42. A calibration curve was also prepared for phosphorus using A.R., B.D.H. potassium dihydrogen phosphate. The known amount of this solution was taken,made to volume in different concentrations and colour was developed as reported earlier. Intensity of the colour was also measured in the same manner. The transmitance readings for standard solutions were plotted against concentrations of phosphorus in the solution. Percentage of phosphorus in a sample was calculated using the following formula:

$$\% \text{ Phosphorus} = \begin{matrix}\text{Transmitance}\\ \text{reading for}\\ \text{a sample}\end{matrix} \times \begin{matrix}\text{gm. of P/degree}\\ \text{of transmitance}\end{matrix} \times 100 \times 100.$$

(iv) and (v) Calcium and potassium: Analyses for these elements were done in the same acid digest, used for the determination of phosphorus in grains, prepared according to method 54(a) as given by USDA Hand-Book No. 60. After making to volume, the required aliquots were taken and analysed fo calcium and potassium. Calcium was determined by following method No. 77 while Potassium was determined with the help of Lang's Flame Photometer using method No. 58(a) . Following are the respective formulae used for calculating percentages of calcium and potassium in the grain samples:

$$\% \text{ Calcium} = \frac{\text{Normality of } KMnO_4 \times 10{,}000 \times KMnO_4 \text{ used in ml.} \times 20}{\text{ml. of aliquot from acid digest}}$$

$$\% \text{ Potassium} = \frac{\begin{matrix}\text{Photometer}\\ \text{reading}\end{matrix} \times \begin{matrix}\text{Vol. of acid}\\ \text{digest made}\end{matrix} \times \begin{matrix}\text{Vol. of}\\ \text{aliquot}\\ \text{made}\end{matrix} \times 100 \times 10^{-6}}{\begin{matrix}\text{Scale standardised to}\\ \text{5 readings for 1 ppm.}\end{matrix} \times \begin{matrix}\text{Vol. of}\\ \text{aliquot taken}\end{matrix}}$$

$$= \frac{R \times 100 \times 50 \times 100 \times 10^{-6}}{5 \times 5} = \frac{R}{50}$$

E. STATISTICAL ANALYSIS

For judging the effects of different treatments on various plant characters studied, all the collected data were subjected to statistical analysis using Fisher's (1950) Analysis of variance Technique. The significance and non-significance of various treatments' effect was judged with the help of 'F' values (test). Critical differences were calculated to assess the significance of difference between treatment means, wherever they were found significant (Panse and Sukhatme, 1961). A skeleton of procedures adopted for various statistical analyses is given in the end (Appendix Table No. X)

EXPERIMENTAL RESULTS

RESULTS of the field experiment, entitled 'Comparative performance of two varieties of maize under single versus split application of different levels of nitrogen', conducted in the *Kharif* season of 1962-'63 at the college farm are presented in this chapter. During the course of investigation, observations on various attributes of growth, yield and quality of the crop were recorded. The processed data for these attributes were subjected to statistical analysis and the Analysis of Variance for these data is given in the Appendix tables at the end. For the sake of better understanding the same have been presented graphically particularly when recorded at periodic intervals. Before presenting the data it is deemed necessary to give a brief account of march of the crop in relation to weather conditions.

March of the crop in relation to weather conditions:

The experimental crop was sown on 3rd July. Because of timely rainfall and pre-sowing irrigation there was sufficient moisture in the soil, which ensured proper germination and good growth of young seedlings. Distribution of rainfall during the month of July was very uniform but total amount of rain was rather insufficient. During the next month, which was comparatively very dry, symptoms of partial wilting were noticed, which culminated in poor initial growth. This necessitated the use of one irrigation in order to restore the vigour of the crop. Irrigation at this critical period of crop growth accelerated the rate of growth. But due to inadequate rainfall during the later part of August and earlier part of September, this irrigation failed to produce, any material gain in terms of growth and yield of the crop. Had there been sufficient rains in the main growing period of the crop, much higher attainments in terms of growth and yield might have been realised.

A. GROWTH CHARACTERS:

1. Dry matter production per plant:

The data for the dry matter production per plant at successive stages of life-cycle of the crop were subjected to statistical analysis (Analysis of Variance Appendix Table I). It was seen that variations in this character were significant due to the effect of varieties at 84 days after sowing; control versus nitrogen at 63 and 84 days after sowing and those due to various levels of nitrogen at 63 days after sowing. Effects of time of application of nitrogen were found to be non-significant at every stage of measurement. Combined effects of levels of nitrogen and varieties were significant at 21 and 84 days after sowing, whil those due to levels and times of application of nitrogen at 21 days after sowing. The effects due to second order interaction were also found to be significant at 21 days after sowing. But combined effects of varieties and times of application of nitrogen were found to be non-significant.

Average results for all the main effects are given in Table 2 and presented graphically in Fig. 5. Values for dry-matter production per plant due to the effect of significant interactions are given after describing the main results.

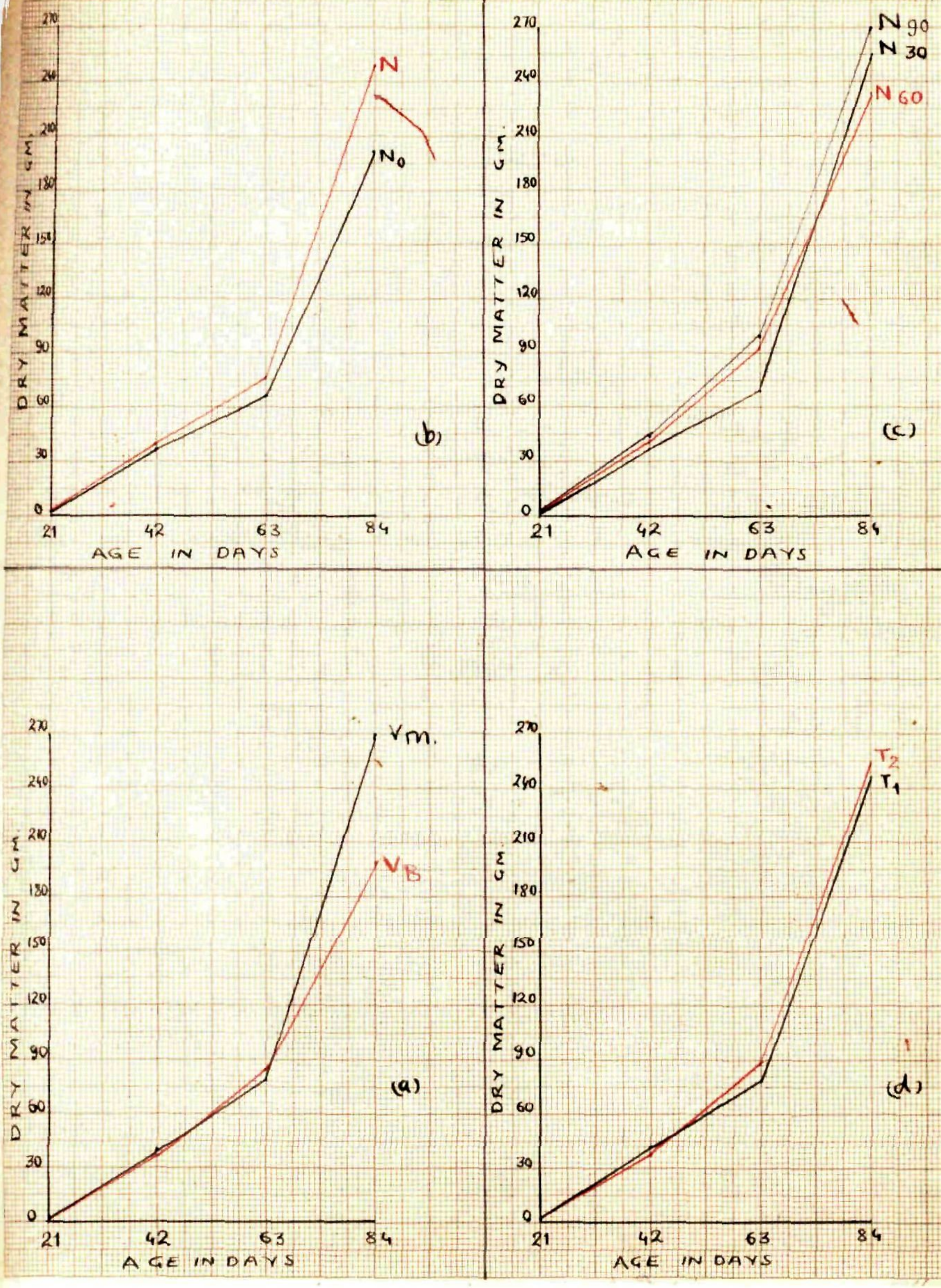
DRY MATTER IN GM.
270
240
210
180
150
120
90
60
30
0
21
42
63
84
AGE IN DAYS
N
N₀
(b)
N 90
N 30
N 60
(c)
Vm.
VB
(a)
T2
T1
(d)

Table 2 - Effect of varieties; levels and time of application of nitrogen on dry-matter production (gm./plant).

Treatments	Age in days			
	21	42	63	84
V_M	1.54	40.17	77.82	268.87
V_B	1.43	38.25	83.57	204.15
S.Em. ±	0.10	2.36	4.25	13.13
L.S.D. (P=0.05)	-	-	-	37.84
Control	1.45	36.03	65.13	201.24
Nitrogen	1.48	40.27	85.88	248.27
S.Em. ±	0.10	2.36	4.25	13.13
L.S.D. (P=0.05)	-	-	9.32	37.84
N_{30}	1.45	37.27	69.03	250.72
N_{60}	1.49	40.80	92.20	233.76
N_{90}	1.50	42.74	96.25	268.49
S.Em. ±	0.15	3.34	6.00	15.65
L.S.D. (P=0.05)	-	-	17.29	-
T_1	1.49	42.55	84.43	245.25
T_2	1.47	37.99	87.33	251.28
S.Em. ±	0.14	2.72	4.90	15.16
L.S.D. (P=0.05)	-	-	-	-

(a) Effect of varieties: An examination of data given in Table 2 and presented in Fig. 5(a) indicates that inspite of the upward trend of dry matter production per plant with variety Malan the differences did not come out to be significant before harvest. At the time of harvest growing of variety Malan resulted in the production of 31.7 per cent more dry matter per plant than that of variety Bassi selected

(b) Effect of Control vs. Nitrogen: An examination of Table 2 and Fig. 5(b) shows consistently greater production of dry-matter per plant with the application of nitrogen at all the stages of crop growth. The minute difference in dry-matter accumulation per plant with the application of nitrogen over control, noted in the beginning ,culminated in significantly increased dry-matter production per plant at 63-and 84 days after sowing, the respective increases being 32.0 and 23.3 per cent. During the periods ranging from 42 to 63 days and again from 63 to 84 days after sowing, plants in control plots accumulated 1.386 gm. and 6.481 gm. dry-matter per day respectively, while the corresponding values in fertilized plots were 2.170 gm. and 7.732 gm. per day.

(c) Effect of levels of nitrogen: The pattern of accumulation of dry-matter per plant under the influence of different levels of nitrogen reveals a smooth trend in dry-matter production per plant with age of the plant (Table 2 and Fig. 5.(c).). At 21, 42 and 63 days after sowing there was a consistentincrease in the dry-matter accumulation by plants with increase in the levels of nitrogen. But at 84 days after sowing, plants from the plots receiving nitrogen @ 33.63 kg./hectare accumulated 7.6 per cent more dry-matter than those receiving 67.26 kg. N/hectare and 7.6 per cent less dry matter than those receiving 100.89 kg.N/hectare. However, dry-matter accumulation was always highest in plants receiving the highest dose of nitrogen i.e. 100.89 kg./hectare. At 63 days after sowing nitrogen applied @ 67.26 kg. and 100.89 kg. per hectare produced 33.56 and 39.14 per cent more dry-matter over 33.63 kg.N/hectare respectively, and the differences were found to be significant.

(d) Effect of time of application of nitrogen: A further examination Table 2 and Fig. 5(d) shows a slight increase in dry-matter production per plant upto 42 days after sowing when all the nitrogen was applied at the time of sowing. But from this time onward a slightly greater dry-matter production per plant was noted when the dose of nitrogen was splitted. However, the differences were never significant.

INTERACTIONS

Table 3 - Combined effect of varieties and nitrogen on dry-matter production (in gm./plant).

Age in days.	Treat-ments.	N_0	N_{30}	N_{60}	N_{90}
21	V_M	1.45	1.49	1.42	1.69
	V_B	1.44	1.42	1.56	1.32
	S.Em.±		0.08		
	L.S.D. (P=0.05)		0.23		
84	V_M	218.88	309.04	268.20	279.75
	V_B	183.99	194.39	200.99	237.23
	S.Em.±		26.26		
	L.S.D. (P=0.05)		75.68		

A perusal of data in Table 3 indicates that different varieties responded differently at different stages of growth to the application of different levels of nitrogen. At 21 days after sowing variety Malan showed a greater increase in dry-matter production with the increasing levels of nitrogen, but a lack of response was noticed in case of variety Bassi selected to doses higher than 67.26 kg.N/ hectare. This is further illustrated by the fact that application of nitrogen @ 100.89 kg./hectare increased dry-matter production per plant of variety Malan but brought about a corresponding reduction in dry-matter per plant when applied to variety Bassi selected. It may, thus, be stated that for more dry-matter production per plant at the initial stage of growth, variety Malan will have to be fertilised at higher level whereas variety Bassi selected would not fair well at the same level.

At 84 days after sowing, application of nitrogen @ 33.63 kg./hectare greatly increased dry matter production per plant over any of the varietal and fertilizer combinations except growing of variety Malan with 100.89 kg.N/hectare. However, there is an indication of greater response of both varieties to increasing levels of nitrogen. Variety Malan produced 19.0 , 74.8 , 34.2 and 17.9 per cent more dry-matter per plant than variety Bassi selected at 0, 33.63, 67.26 and 100.89 kg. of nitrogen per hectare respectively.

Table 4 - Combined effect of levels and time of nitrogen on dry-matter production at 21 days after sowing (gm./plant).

Treatments	N_{30}	N_{60}	N_{90}
T_1	1.35	1.48	1.64
T_2	1.56	1.50	1.85
S.Em.±	0.08		
L.S.D. (P=0.05)	0.23		

In Table 4 a reflection of greater dry-matter production per plant with the application of only half of the dose over the full dose of nitrogen points out to the adverse effects of the application of all nitrogen at one time on the initial growth of the crop. Application of half of the highest dose, i.e. 100.89 kg.N/hectare at 21 days after sowing proved significantly better than the application of even 67.26 kg.N/hectare all at one time. It may, thus, be pointed out that half the amount of any level of nitrogen (33.63, 67.26 or 100.89 kg./hectare) had slightly better effect than it's full dose and that application of 50.445 kg.N/hectare, i.e. half the dose of 100.89 kg.N/hectare, proved better than 67.26 kg.N/hectare applied all at sowing.

Table 5 - Combined effect of varieties; levels and time of application of nitrogen on dry-matter production at 21 days after sowing (gm./plant).

Treatments.	V_M				V_B			
	N_0	N_{30}	N_{60}	N_{90}	N_0	N_{30}	N_{60}	N_{90}
T_1	1.44	1.25	1.63	1.83	1.60	1.44	1.33	1.45
T_2	1.47	1.72	1.21	1.56	1.27	1.40	1.79	1.15
S.Em.±				0.11				
L.S.D. (P=0.05)				0.32				

A critical study of Table 5 reveals greater response of variety Malan to higher levels of nitrogen particularly when they were applied all at one time. Just opposit was the case with variety Bassi selected, which showed decreasing response to increasing levels of nitrogen when applied all at the time of sowing. Split applications of 33.63 kg.N/hectare and 100.89 kg.N/hectare were significantly better than split application of 67.26 kg.N/hectare in case of variety Malan. Split application of 67.26 kg. nitrogen per hectare was significantly superior to its single application in case of variety Bassi selected.

2. Height of plants:

The data for the attainment of height by the plants at successive stages of life cycle of the crop were subjected to statistical analysis (Analysis of Variance, Appendix, Table II) . The variations in height of plant due to the effect of varieties were found to be significant at all the stages of crop growth from 35 to 63 days after sowing while those due to levels of nitrogen were significant at 35 and 63 days after sowing. Variations in height due to time of application of nitrogen were not foun to be significant at any stage of crop growth. Combined effect of levels of nitrogen and their time of application; and that of levels of nitrogen and varieties were found to be significant at 21 and 63 days after sowing respectively. No other first order or second order interactions were found to be significant at any stage of crop growth. The average results for the main effects and only for significant interactions are summarised through the following table and presented graphically in Fig. 6.

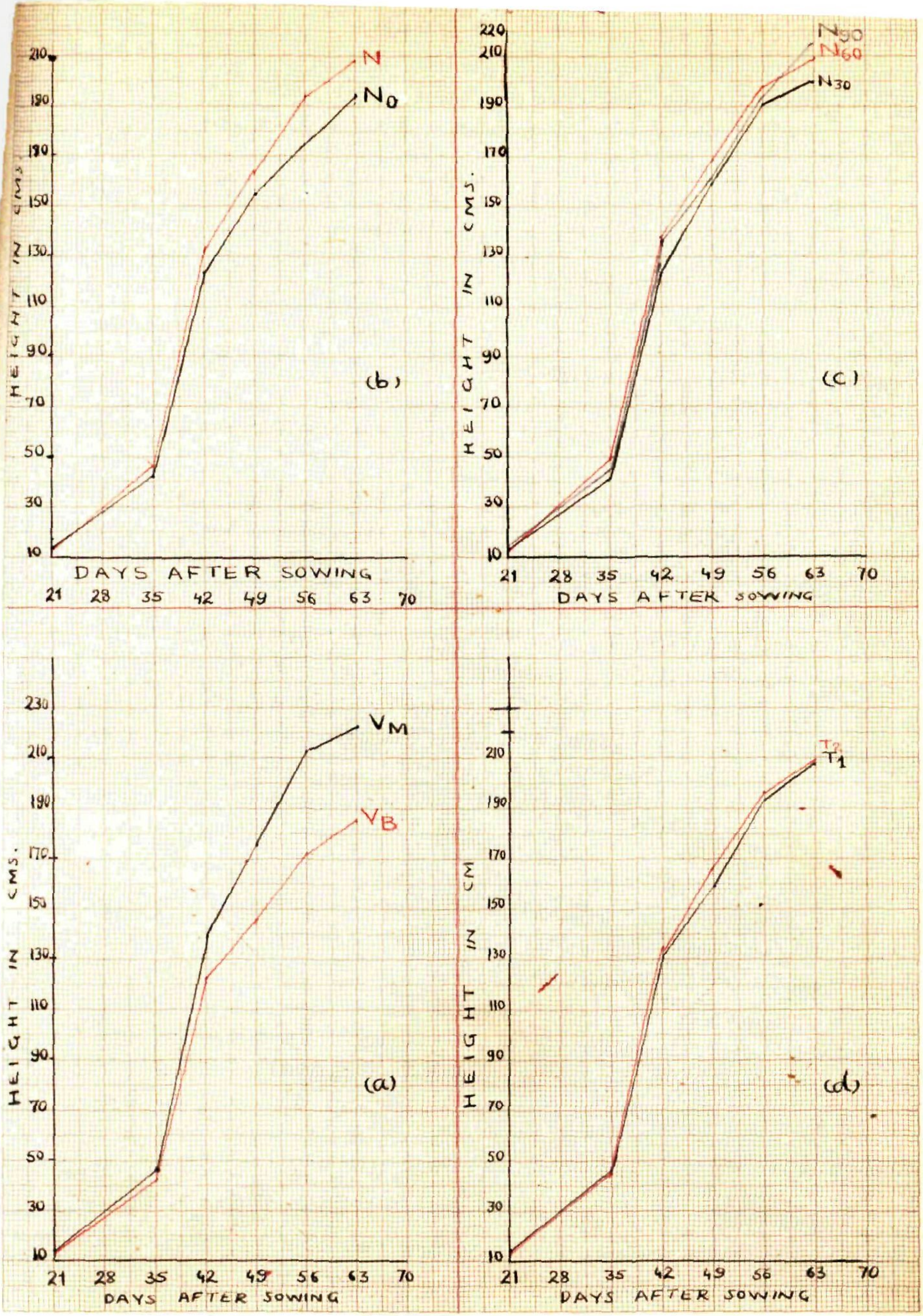
(b)
N
N_0
HEIGHT IN CMS.
DAYS AFTER SOWING
21 28 35 42 49 56 63 70
10 30 50 70 90 110 130 150 170 190 210
(c)
N_{90}
N_{60}
N_{30}
HEIGHT IN CMS.
DAYS AFTER SOWING
21 28 35 42 49 56 63 70
10 30 50 70 90 110 130 150 170 190 210 220
(a)
V_M
V_B
HEIGHT IN CMS.
DAYS AFTER SOWING
21 28 35 42 49 56 63 70
10 30 50 70 90 110 130 150 170 190 210 230
(d)
T_2
T_1
HEIGHT IN CM
DAYS AFTER SOWING
21 28 35 42 49 56 63 70
10 30 50 70 90 110 130 150 170 190 210

Table 6 - Effect of varieties; levels and time of application of nitrogen on attainment of height (cm./plant).

Treat- ments.	Age in days					
	21	35	42	49	56	63
V_M	13.95	47.33	138.05	175.90	211.66	222.18
V_B	13.16	42.22	122.41	145.54	172.41	185.17
S.Em.±	0.48	1.17	3.07	2.52	2.81	2.92
L.S.D. (P=0.05)	-	3.38	8.85	7.26	7.09	7.41
Control	13.65	42.06	123.82	155.30	184.66	191.50
Nitrogen	13.55	45.66	132.36	162.52	194.46	207.86
S.Em.±	0.48	1.17	3.07	2.52	2.81	2.92
L.S.D. (P=0.05)	-	-	-	-	7.09	7.41
N_{30}	13.28	40.95	123.78	158.52	190.96	199.10
N_{60}	13.19	49.09	137.85	168.58	197.73	209.33
N_{90}	14.17	46.99	135.45	160.48	194.76	215.22
S.Em.±	0.68	1.66	4.34	3.56	3.95	4.13
L.S.D. (P=0.05)	-	4.78	-	-	-	11.91
T_1	14.06	45.87	130.61	159.09	193.26	206.75
T_2	13.03	45.38	134.11	165.97	195.71	209.01
S.Em.±	0.56	1.35	3.55	2.90	3.25	3.37
L.S.D. (P=0.05)	-	-	-	-	-	-

(a) Effect of varieties: An examination of data from Table 6 and Fig. 6(a) indicates the superiority of variety Malan in the attainment of height by plants at all stages of crop growth over variety Bassi selected. Except for the initial period, i.e. at 21 days after sowing.differences in the attainment of height by plants were found to be significant from 35 days after sowing till harvest of the crop. When compared with Bassi selected, the attainments of height by Malan were 6.0, 12.8, 12.8, 20.8, 27.7 and 20.0 per cent higher at 21, 35, 42, 49, 56 and 63 days after sowing respectively. It may, thus, be concluded that Malan variety attained on an average 20 per cent more height at the later stages of crop growth.

(b) <u>Effect of control vs. nitrogen:</u> An examination of data (Table 6 and Fig. 6(b)) indicates that application of nitrogen, irrespective of levels, resulted in a greater height of plants at all the stages of crop growth over control, except at the initial stage of 21 days after sowing. Application of nitrogen tended to produce significant differences, in attainment of height by the plants, over control at 56 and 63 days after sowing. But non-significant differences in height were observed at other stages of crop growth. At the time of harvest the application of nitrogen caused 8.5 per cent increase in mean height of the plants over control.

(c) <u>Effect of levels of nitrogen:</u> A perusal of data (Table 6 and Fig. 6(c)) indicates that application of increasing levels of nitrogen brought about significant differences in mean height of the plants at 35 days after sowing and at the time of harvest. Height of the plant in general tended to increase with an increase in the levels of nitrogen from 21 days after sowing till harvest but at 42, 49 and 56 days after sowing application of 100.89 kg.N/hectare not only failed to produce any increase in plant height but rather retarded the height of plants. However, the differences were never significant during the period ranging from 42 to 56 days after sowing. At the time of harvest applications of 33.63, 67.26 and 100.89 kg. nitrogen per hectare increased the plant height by 3.9, 9.3 and 12.3 per cent respectively over control.

(d) Effect of time of application of nitrogen: A study of Table 6 and Fig 6(d) reveals that in the initial stages of growth, i.e. upto 35 days after sowing, application of whole amount of nitrogen at sowing appeared to be slightly better than it's split application. But from 42 days after sowing, application of nitrogen half at sowing and half at tasseling tended to increase plant height over it's single application at the time of sowing, and the same trend was maintained till harvest. These differences at all the stages of growth were, however, non-significant.

INTERACTIONS:

Table 7 - Combined effect of varieties and levels nitrogen on height of the plant at 63 days after sowing (in cm./plant).

Treatment	N_0	N_{30}	N_{60}	N_{90}
V_M	103.70	110.25	114.96	115.46
V_B	87.80	88.85	94.36	99.85
S.Em.±		5.84		
L.S.D. (P=0.05)		14.68		

An examination of data in Table 7 indicates that different varieties responded differently to the application of different levels of nitrogen as far as the attainment of height by plants was concerned. It was observed that variations in the attainment of height by plants of either variety Malan or variety Bassi selected due to any level of nitrogén were found to be non-significant at 63 days after sowing. But at all other stages the differences in the attainment of height by the plants of these two varieties were significant at every level of nitrogen. Variety Malan maintained it's superiority over variety Bassi selected at all levels of nitrogen. Application of nitrogen @ 33.63, 67.26 and 100.89 kg./hectare to variety Malan gave an increase in the mean height of plants by 6.3, 10.8 and 11.3 per cent respectively over control, where as in variety Bassi selected the corresponding values were 1.2, 7.5 and 13.8 per cent.

Thus, it may be stated that application of nitrogen @ 33.63 and 67.26 kg./hectare gave more increase in height over control in variety Malan than in variety Bassi selected, while 100.89 kg.N/hectare gave more increase in height in variety Bassi selected than in variety Malan.

Table 8 - Combined effect of levels and time of application of nitrogen on height at 21 days after sowing (cm./plant).

Treatment	N_{30}	N_{60}	N_{90}
T_1	13.35	12.49	16.34
T_2	13.21	13.88	11.99
S.Em.±		0.96	
L.S.D. (P=0.05)		2.77	

From Table 8 it is clear that time of application of nitrogen upto 67.26 kg./hectare had no effect in terms of height of the plant. It is only after this level that height of the plant was affected. Application of nitrogen @ 100.89 kg./hectare,all at the time of sowing proved to be the best treatment where-as split application of the same level resulted in significant reduction of plants' height.

3. Nitrogen contents of plants:

The data for nitrogen content of the plant at each successive stages of life cycle of the crop were subjected to statistical analysis (Analysis of Variance,

Appendix Table III) . Variations due to the varieties of maize and control versus application of nitrogen came out to be significant in the analysis of data for nitrogen percentage only at 63 days after sowing. Variations in the nitrogen content of plants due to the effect of different levels of nitrogen and time of application of nitrogen were significant at 21, 63 and 84 days after sowing in the first case and only at the last stage in the second case. Combined effects of levels of nitrogen and their time of application were also significant at 84 days after sowing. No other first order or second order interactions were found to be significant at any stage of crop growth.

Average results for all the main effects are given in Table 9 and presented graphically in Fig. 7 . Mean values for nitrogen content of plants due to the effect of only significant interactions are given in the following pages.

Table 9 - Effect of varieties; levels and time of application of nitrogen on the average nitrogen content of plants (per cent).

Treatments	Age in days			
	21	42	63	84
V_M	3.699	2.407	1.185	1.145
V_B	3.708	2.503	1.470	1.127
S.Em.±	0.273	0.151	0.050	0.025
L.S.D. (P=0.05)	-	-	0.146	-
Control	3.655	2.466	1.598	1.147
Nitrogen	3.706	2.458	1.327	1.139
S.Em.±	0.273	0.151	0.050	0.025
L.S.D. (P=0.05)	-	-	0.146	-
N_{30}	3.522	2.459	1.204	1.057
N_{60}	3.813	2.309	1.291	1.193
N_{90}	3.776	2.598	1.487	1.166
S.Em.±	0.386	0.253	0.074	0.035
L.S.D. (P=0.05)	-	-	0.214	0.101
T_1	3.771	2.430	1.343	1.093
T_2	3.635	2.480	1.312	1.184
S.Em.±	0.315	0.209	0.605	0.029
L.S.D. (P=0.05)	-	-	-	0.082

(a) Effect of varieties: A comparison of data given in Table 9 and present through Fig. 7(a) indicates that plants of variety Bassi selected analysed high nitrogen than those of Malan at 21, 42 & 63 days after sowing but low at 84 days after sowing. At 63 days after sowing plants of variety Bassi selected contained 24 per cent more nitrogen than those of variety Malan. However, at the last stage of growth plants of variety Malan contained 1.5 per cent more nitrogen than those of variety Bassi selected but the difference was non-significant.

(b) Effect of control vs. nitrogen: An examination of Table 9 and Fig. 7(b) reveals that except for the period, ending 21 days after sowing, application of fertiliser tended to slightly reduce the nitrogen content of the plant. At 63 days after sowing application of fertiliser significantly had a pronounced reducing effect on nitrogen content of plant, as the plants receiving fertilizers contained 20.3 per cent less nitrogen than those which received no fertiliser. Thus, it may be stated that the application of nitrogenous fertilizer failed to increase the nitrogen content of plants in the later stages of crop growth.

(c) Effect of levels of nitrogen: The data, given in Table 9 and illustrated graphically in Fig 7(c) , when compared among themselves, indicate that application of different levels of nitrogen brought about widely varying results. Application of nitrogen @ 100.89 kg./hectare at 63 days after sowing and that of 33.63 kg. and 67.26 kg. per hectare at 21 and 84 days after sowing resulted in the production of plants very rich in nitrogen as compared to those with 33.63 kg. nitrogen per hectare and the variations in the nitrogen content of plants due to them were found to be significant. But variations in the nitrogen content of plants due to different levels of nitrogen were found to be non-significant at 42 days after sowing. In the ultimate analysis, plants receiving 67.26 kg. of nitrogen per hectare contained 12.9 and 2.3 per cent more nitrogen than those receiving 33.63 kg. and 100. 89 kg. of nitrogen per hectare respectively.

(d) Effect of time of application: A critical study of data given in Table 9 and presented in Fig. 7(d) reveals that application of all the amount of nitrogen at sowing time decreased the nitrogen content of the plants at 84 days after sowing as compared to that with the split application of nitrogen. The per cent increase in the nitrogen content of the plant with the split application of nitrogen over its single application was 8.3 . Variations, in the nitrogen content of the plants, due to time of application of fertiliser were found to be non-significant at all the other stages of crop growth.

INTERACTION:

Table 10 - Combined effect of levels and time of application on the average nitrogen content of plants at 84 days after sowing(%).

Treatments	N_{30}	N_{60}	N_{90}
T_1	1.055	1.203	1.022
T_2	1.059	1.184	1.309
S.Em.±		0.050	
L.S.D. (P=0.05)		0.144	

An examination of data given in Table 10 indicates that application of nitrogen in doses higher or lower than 66.26 kg./hectare significantly reduced nitrogen content of the plants when all the amount of nitrogen was applied at the time of sowing. When split application of nitrogen was made, maximum nitrogen content of the plants occurred with the application of highest dose, i.e. 100.89 kg./hectare and nitrogen content of the plants receiving the lowest dose, i.e. 33. 63 kg./hectare was significantly lower than that under this treatment. Thus, it may be stated that the effect of the application of nitrogen @ 33.63 kg. and 66.26 kg. per hectare did not undergo any change but the effect 100.89 kg. of nitrogen per hectare registered a very great change with the time of application and greatly increased the nitrogen content of the plant when applied half the amount at the time of sowing and the remaining half at the time of tasseling.

B. GRAIN AND COB YIELDS AND VARIOUS ATTRIBUTES AFFECTING THEM.

Data for grain yield per hactare, grain yield per plant, number of cobs per plot in first picking, number of cobs per plot in second picking, total number of cobs per plot, number of cobs per plant, weight of cobs per plot, and final crop stand per plot were subjected to statistical analysis (Analysis of Variance, Appendix Tables IV & V). Variations due to the effect of varieties, control versus nitrogen application, levels of nitrogen and time of application of nitrogen were found to be significant for grain yield per hectare. Variations in grain yield per plant, number of cobs per plot in first picking, total number of cobs per plot, weight of cobs per plot also underwent significant changes due to varietal fertilization differences. Variations in number of cobs per plot in second picking were found to be significant due to application and time of application of nitrogen, irrespective of it's levels. Neither the levels of nitrogen nor the time of application of nitrogen had any effect on grain yield per plant, number of cobs per plot in first picking, total number of cobs per plot and weight of cobs per plot. Plant population did not undergo any changes due to the effect of varieties, time or level of fertilizer, application. Thus, variations in grain and cob yields will have to be explained on the basis of characters other than crop stand.

Combined effects of varieties and levels of nitrogen, and varieties and time of application of nitrogen were found to be significant in the analysis of data in grain yield per hectare; varieties and levels of nitrogen in weight of cobs per plot; and varieties, levels and time of application of nitrogen in number of cobs per plot in second picking. Average results for all the main effects are given in Table 10 and 14 and those for the significant interactions in subsequent tables.

I. **Grain Yield:**

Table 10- **Effect of varieties; levels and time of application of nitrogen on grain yield characters.**

Treat-ments.	Grain yield				No. of plants per plot.
	qu./ha.	gm./per plant	gm./ per cob.	gm.per 1,000 grain	
V_M	29.76	87.28	85.42	211.25	192.00
V_B	19.23	72.34	67.67	144.67	183.80
S.Em.±	0.71	2.80			3.11
L.S.D. (P=0.05)	2.05	8.08			-
Control	17.64	68.60	70.34	167.50	181.80
Nitrogen	24.24	83.53	78.62	181.44	193.40
S.Em.±	0.71	2.80			3.11
L.S.D. (P=0.05)	2.05	8.08			-
N_{30}	20.86	79.48	75.23	171.00	185.80
N_{60}	25.61	85.58	81.70	180.00	193.40
N_{90}	26.30	85.53	78.91	187.33	192.60
S.Em.±	1.00	3.96			4.28
L.S.D. (P=0.05)	2.88	-			-
T_1	22.22	86.11	82.27	178.00	190.70
T_2	26.26	80.95	74.95	184.88	190.60
S.Em.±	0.82	3.24			3.59
L.S.D. (P=0.05)	2.36	-			-

(a) Effect of varieties: A critical study of Table 10 brings about the fact that variety Malan resulted in greater production of grain per hectare, per plant, per cob and gave higher test-weight than variety Bassi selected. The difference in all these characters were more or less uniform and point to over all better effect of variety Malan over variety Bassi selected. The respective increases in grain yield per hectare, per plant, per cob and in test weight due to growing of variety Malan were 54.74, 20.65, 26.23 and 31.51 per cent over those of variety Bassi selected.

(b) Effect of fertilisation: Like that of variety Malan application of fertilisers also brought about marked increases in grain yield per hectare, per plant, per cob and gave higher test-weight and the respective increases over control were 37.41, 21.76, 11.77 and 8.03 per cent.

While comparing different levels of nitrogen it was observed that application of 67.26 kg. and 100.89 kg. nitrogen per hectare significantly increased the grain yield per hectare by 23.25 and 26.66 per cent respectively over that with 33.63 kg.N/hectare. The addition of each 33.63 kg.N/hectare brought about an increase in grain yield (per hectare) by 18.12 per cent over control,22.78 per cent over 33.63 kg.N/hectare and 2.71 per cent over 67.26 kg.N/hectare; whereas application of 66.26 kg.N/hectare and 100.89 kg.N/hectare resulted in an increase in grain yield (per hectare) by 45.17 per cent and 49.11 per cent respectively over control. Highest grain yield of 26.30 quintals per hectare and test- weight (187.33 gm.) were recorded with the application of highest level of nitrogen, i.e. 100.89 kg. per hectare.

Application of additional dose of 33.63 kg.N/ hectare 33.63 kg.N/hectare tended to increase grain yield per plant and per cob and test-weight. Application of additional dose of 33.63 kg. N/hectare over 67.26 kg.N/ hectare did not have any favourable effect but on the contrary it brought about a slight reduction in yield per plant and yield per cob.

Thus, it may be concluded that application of 66.26 kg. nitrogen per hectare brought about a consistent increase in grain yield per hectare, per plant, per cob and in also test-weight over that of 33.63 kg. nitrogen per hectare by 22.78, 7.67, 8.60 and 5.26 per cent respectively.

(c) Effect of time of application of nitrogen: Application of fertilizer half at sowing and other half at tasseling increased grain yield per hectare by 18.14 per cent, and test-weight by only 3.86 per cent; but slightly reduced grain yield per plant and per cob.

There was a reflection of greater number of plants due to growing of variety Malan, receiving 67.26 kg. nitrogen per hectare and also due to applying all the amount of nitrogen at the time of sowing; but the differences were never significant.

INTERACTIONS:

Table 11 - Combined effect of varieties and levels of nitrogen on grain yield (in quintals per hectare).

Treatments	N_0	N_{30}	N_{60}	N_{90}
V_M	22.00	27.80	32.90	36.40
V_B	13.30	13.90	18.30	16.20
S.Em.±		0.64		
L.S.D. (P=0.05)		1.84		

The data in Table 11 brings about striking difference in the response of variety Malan and variety Bassi selected to increasing levels of nitrogen. Application of every 33.63 kg. N/hectare brought about a significant increase in grain yield per hectare at significant rates in variety Malan, and highest yield of 36.4 quintals per hectare was recorded with the highest level of nitrogen i.e. 100.89 kg. per hectare. Application of 67.26 kg. nitrogen per hectare gave significantly higher grain yield over control or anlower or higher level than this. Application of 33.63 kg., 67.26 kg. and 100.89 kg. nitrogen per hectare tended to give 26.36, 49.55 and 65.86 per cent more yield respectively over control in variety Malan while in variety Bassi selected they tended to increase the grain yield by 0.45, 3.76 and 2.17 per cent respectively over control. Grain yields per hectare of variety Malan with the application of 67.26 kg. and 100.89 kg. nitrogen per hectare were more than two times of those obtained with variety Bassi selected at the same levels of fertilisers.

Table 12 - Combined effect of varieties and time of application of nitrogen on grain yield in quintals per hectare).

Treatments	V_M	V_B
T_1	28.53	15.93
T_2	36.20	16.67
S.Em.±	0.37	
L.S.D. (P=0.05)	1.06	

Split application of nitrogen brought about significantly higher grain yield in Malan but not in Bassi selected. Irrespective of time of application of fertiliser variety Malan produced significantly higher grain yields than variety Bassi selected. Application of nitrogen half at the time of sowing and the remaining half at the time of tasseling tended to increase the grain yield by 23.4 per cent per hectare in Malan and by 4.6 per cent per hectare in Bassi selected, over the single application of nitrogen applied all at the time of sowing.

II Cob Yield:

Table 14 - Effect of varieties; levels and time of application of nitrogen on cob yield characters.

Treatments.	No. of cobs per plot			No. of cobs/plant	Wt. of cobs/plot kg.
	In 1st picking.	In 2nd picking.	Total		
V_M	194.00	14.60	208.60	1.072	15.43
V_B	135.50	27.00	162.50	1.100	8.43
S.Em.±	4.19	2.82	4.03	0.070	0.35
L.S.D. (P=0.05)	12.05	8.06	11.61	-	1.00
Control	148.40	19.00	167.40	1.075	9.48
Nitrogen	170.20	21.40	191.60	1.092	13.59
S.Em.±	4.19	2.82	4.03	0.070	0.35
L.S.D. (P=0.05)	12.05	-	11.61	-	1.00
N_{30}	159.00	19.90	188.90	1.083	11.77
N_{60}	178.00	24.10	202.10	1.092	14.66
N_{90}	173.50	20.30	193.80	1.083	14.33
S.Em.±	7.42	4.01	7.24	0.099	0.49
L.S.D. (P=0.05)	-	-	-	-	-
T_1	167.00	16.20	183.20	1.089	13.29
T_2	173.40	26.60	200.00	1.083	13.89
S.Em.±	6.06	3.27	5.92	0.812	0.40
L.S.D. (P=0.05)	-	9.45	-	-	-

(a) Effect of varieties: On an examination of Table 14 it may be indicated that growing of variety Malan gave significantly greater number of cobs than variety Bassi selected in their respective first pickings; whereas in their second pickings variety Bassi selected significantly surpassed variety Malan as far as number of cobs per plot in second picking is concerned. However, variety Malan yielded significantly increased number of cobs and weight of cobs per plot and respective increases were 28.3 and 83.0 per cent. There were no variations in number of cobs per plant due to growing of different varieties.

(b) Effect of fertilization: Application of nitrogen, irrespective of levels tended to bring about significant increases in per plot number of cobs in first picking, total number of cobs and yield of cobs and their respective increases were 14.7 , 14.4 and 43.3 per cent. However, the variations in number of cobs per plot in second picking and in number of cobs per plant due to the application of nitrogen were never significant.

While comparing among themselves, it may be observed that different levels of nitrogen did not bring about any significant variations in number of cobs per plot - in first picking, in second picking; total number of cobs per plot, number of cobs per plant or in the yield of cobs per plot. However, there seems to be an increasing tendency in each character due to the application of 67.26 kg.N/hectare over a lower or higher dose than this.

(c) Effect of time of application of nitrogen: Data given in Table 14 reveal that time of application of nitrogen did not cause any variations in any of the attributes of cob yield, except number of cobs per plot in second picking. Split application of nitrogen tended to give significantly greater number of cobs in the second picking and the increase was noted to be 64.2 per cent over single application of nitrogen.

INTERACTIONS:

Table 15 - Per plot number of cobs of different varieties in the second picking as affected by levels of nitrogen and time of fertilization.

Treatments	V_M				V_B			
	N_0	N_{30}	N_{60}	N_{90}	N_0	N_{30}	N_{60}	N_{90}
T_1	13.33	14.66	14.00	12.00	21.33	19.66	14.66	23.33
T_2	10.33	15.33	19.00	18.33	31.33	30.00	48.66	28.66
S.Em.±				0.80				
L.S.D. (P=0.05)				2.31				

After a critical study of Table 15 it may be stated that the application of nitrogen (when compared at any level) half at the time of sowing and the other half at the time of tasseling tended to give a greater number of cobs per plot in the second picking of both the varieties over the application of all the amount of nitrogen at the time of sowing. Not only the split application of nitrogen but also the single application of nitrogen gave more cobs in the second picking with the variety Bassi selected than the variety Malan at any level of nitrogen. Split application of 67.26 kg.N/hectare on an average gave the highest number of cobs in the second picking with both the varieties. However, the split application of the highest level of nitrogen application was slightly inferior to split application of 67.26 kg.N/hectare but greatly superior to control and split application of 33.63 kg.N/hectare in variety Malan; whereas it was highly inferior to control and to the split application of other levels of nitrogen, in variety Bassi selected. When compared within the single application of various levels of nitrogen highest level of nitrogen i.e. 100.89 kg./hectare gave the highest number of cobs in the second picking of variety Bassi selected whereas it gave the lowest number of cobs in the second picking of variety Malan.

Table 16- Combined effect of levels of nitrogen and varieties on yield of cobs (kg.).

Treatments	N_0	N_{30}	N_{60}	N_{90}
V_M	11.458	14.333	16.958	18.958
V_B	7.500	9.208	12.366	9.708
S.Em. ±		0.220		
L.S.D. (P=0.05)		0.634		

The results mentioned in Table 16 reveal that variety Malan gave higher cob yield at any level of nitrogen than variety Bassi selected. Variety Malan showed an increasing trend in the cob yield with the increase in the levels of nitrogen and highest cob yield per plot was obtained with the highest level of nitrogen application (100.89 kg.N/hectare) whereas variety Bassi selected showed this type of trend only upto the application of 67.26 kg.N/hectare but application of 100.89 kg.N/hectare retarded the yield of cob. Highest yield of cobs of variety Bassi selected was obtained with 67.26 kg.N application and which was less than the yield of cobs obtained at any level of nitrogen with variety Malan. When compared with their respective controls variety Malan gave the highest extra cob yield of 65.45 per cent at 100.89 kg.N/hectare while variety Bassi selected gave the highest extra yield of 64.88 per cent at 67.26 kg.N/hectare over their respective controls.

D. STOVER YIELD CHARACTERS:

The data for stover yield per hectare, dry-matter production per plant and height per plant were subjected to statistical analysis. Significant variations in the stover yield, dry-matter production and final height of the plant were noted due to the effect of varieties and also due to the application of nitrogen. (Analysis of Variance, Appendix Table VI) Differences in different levels of nitrogen and time of application of nitrogen brought about significant changes in stover yield per hectare and plant height and stover yield respectively. Combined effect of varieties in presence of different levels of nitrogen and different time of application of nitrogen were also found to be statistically significant on stover yield per hectare. Average results for all the main effects are given in the following table.

Table 17 - Effect of varieties, time of application and levels of nitrogen on stover yield characters(at harvest).

Treat-ments	No. of plants/ plot.	Dry-matter/ plant in gm.	Height/ plant in cm.	Stover yield/ hectare in quintals.
V_M	192.00	268.87	222.18	69.79
V_B	183.80	204.15	185.17	51.79
S.Em.±	3.11	13.13	2.92	2.00
L.S.D. (P=0.05)	-	37.84	7.41	5.88
Control	181.80	201.24	191.50	49.58
Nitrogen	193.40	248.27	207.86	64.20
S.Em. ±	3.11	13.13	2.92	2.00
L.S.D. (P=0.05)	-	37.84	7.41	5.88
N_{30}	185.80	251.72	199.10	55.40
N_{60}	193.40	233.76	209.33	66.38
N_{90}	192.60	268.49	215.22	70.99
S.Em.±	4.28	15.65	4.13	2.83
L.S.D. (P=0.05)	-	-	11.91	8.17
T_1	190.70	245.25	206.75	58.27
T_2	190.60	251.28	209.01	70.13
S.Em.±	3.59	15.16	3.37	2.31
L.S.D. (P=0.05)	-	-	-	6.67

(a) Effect of varieties: Growing of variety Malan resulted in the production of greater stover yield, per plot, dry-matter per plant and attainment of height, with that of Bassi selected. Growing of variety Malan increased stover yield per hectare by 36.6 per cent, dry-matter per plant by 31.7 per cent and height per plant by 20.0 per cent over that of Bassi selected.

(b) Effect of fertilisation: The effects of fertilizer were similar to those of varieties.when compared with check plots, application of nitrogen resulted insignificantly increased production of stover yield, drymatter per plant and height of plant by 29.5 , 23.0 and 8.5 per cent respectively.

Application of different levels of nitrogen, however, did not have the same effect as referred above. Except for dry-matter production per plant application of increasing levels of nitrogen tended to increase stover yield per hectare and final height of the plant. But no additional advantages appeared to have resulted by increasing the dose beyond 67.26 kg. nitrogen per hectare.

(c) Time of application of nitrogen: Time of application of nitrogen brought about slight variations in the production of dry-matter and attainment of height by plants. But compared with single application of allthe amount of nitrogen at the time of sowing, split application of nitrogen (half at the time of sowing and the other half at the time of tasseling) significantly increased the stover yield per hectare by 20.3 per cent.

D. NUTRIENT CONTENTS OF GRAINS

The data for crude protein, phosphorus, potassium and calcium contents of the grains were subjected to statistical analysis (Analysis of Variance, Appendix Table VII). Chemical analysis of grains for their true protein content was done treatment wise thus, its statistical analysis could not be done. However, the average results for all the main effects are given in the following table.

Table 18 - Effect of varieties; levels and time of application on the nutrient contents of grain (per cent).

Treat-ments.	Proteins		Minerals		
	Crude	True	Phos-phorus	Pota-ssium	Calcium
V_M	9.509	5.807	0.383	0.430	0.238
V_B	9.402	5.877	0.394	0.454	0.183
S.Em.±	0.273	-	0.011	0.017	0.044
L.S.D. (P=0.05)	-	-	0.032	0.052	-
Control	9.166	5.375	0.385	0.437	0.195
Nitrogen	9.552	6.114	0.390	0.443	0.211
S.Em.±	0.273	-	0.011	0.017	0.044
L.S.D. (P=0.05)	-	-	-	-	-
N_{30}	8.952	5.928	0.386	0.443	0.197
N_{60}	9.400	6.268	0.397	0.443	0.200
N_{90}	10.304	6.136	0.386	0.443	0.235
S.Em.±	0.386	-	0.016	0.025	0.062
L.S.D. (P=0.05)	1.112	-	-	-	-
T_1	9.799	6.551	0.390	0.444	0.213
T_2	9.309	5.670	0.390	0.442	0.208
S.Em.±	0.315	-	0.013	0.021	0.051
L.S.D. (P=0.05)	-	-	-	-	-

(a) <u>Effect of varieties:</u> Significant varietal differences were noted in terms of phosphorus and potassium content of grain. Variety Bassi selected showed higher percentages of phosphorus and potassium contents in grain as compared to that of variety Malan. But greater phosphorus and potassium contents of grain were associated with lower calcium content like phosphorus and potassium true protein and crude protein contents were also slightly higher in variety Bassi selected but the differences were non-significant.

(b) <u>Effect of fertilization:</u> Application of nitrogen fertilizer did not result in any definite increase or decrease in all the characters studied under this heading (viz. per cent crude protein, true protein, phosphorus, potassium and calcium). Application of nitrogen fertilizer slightly increased true and crude proteins, phosphorus and calcium contents in grain but slightly reduced potassium content in grain. The differences were however non-significant.

When different levels of nitrogen were compared among themselves. It was observed that application of 67.26 kg. nitrogen per hectare (60 lb. nitrogen per acre) slightly increased true protein, crude protein, phosphorus and calcium contents of grain. But application of 100.89 kg. nitrogen per hectare, which decreased true protein, crude protein and phosphorus contents of grain further increased calcium content of grain over application of 33.63 kg. nitrogen per hectare. However, potassium content was not affected by any of the levels of nitrogen.

(c) Effect of time of application of nitrogen: Single application of fertilizers slightly increased crude protein, potassium and calcium content of grain. But brought about corresponding reduction in true protein and phosphorus contents of grain.

It may, thus, be concluded that varietal responses in the absorption and concentration of nutrients were more pronounced than fertilizer treatments. Growing of variety Bassi selected, which is an early maturing variety, contained more crude protein, true protein, phosphorus and potassium but has less calcium content in the grains. Time and levels of fertilizer application did not materially change the nutrient contents of grains. However, single application of nitrogen (all at the time of sowing) brought about slight increase in almost all the constituents and the effect of 67.26 kg. nitrogen per hectare (60 lb. nitrogen per acre) were more pronounced in all the nutrient contents of grains

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DISCUSSION

RESULTS, obtained and presented in the preceding chapter, are discussed here. In order to find out appropriate explanation for them, references to work of other authors are cited as and when required.

A. GRAIN YIELD PER HECTARE

It is well known fact that grain yield per hectare is the function of number of plants growing in that area and grain yield per plant. As far as maize crop is concerned grain yield per plant is the reflection of number of cobs per plant and weight of grains per cob. Thus, variations in grain yield will have to be explained on the basis of variation in crop stand , yield per plant and other attributes of yield. As the crop stand was more or less constant in this experiment marked variations in grain yield per hectare will have to be traced to variations in grain yield per plant and in other attributes of yield. A reference to Table 13 indicates that significant variations in the grain yield per hectare were brought about by growing of different varieties with different levels of nitrogen applied at different times.

1. Effect of varieties: Growing of variety Malan resulted in significantly greater production of grain per hectare as compared to that of variety Bassi selected. Increased grain yield per hectare under variety Malan was associated with improved grain yield per plant which in turn appears to have

been brought about by consistently greater production of dry matter per plant at successive stages of crop growth culminating increased height of plant, number of cobs per plot, yield of cobs per plot, weight of grains per cob, and weight of 1000 kernels. The over all improvement in the grain yield per plant and various other attributes of yield in plants of variety Malan may be ascribed partly to greater inherent genetic potential in this variety as compared to that in variety Bassi selected and partly to greater span of life-cycle in the former than the latter. Thus, plants of variety Malan might have utilized the available nutrients and moisture in a much efficient manner and for a longer period than those of variety Bassi selected; ultimately resulting in much higher out-turns. Bhatnagar (1957), from yield trials conducted at Udaipur, also reported that Malan out-yielded variety Bassi selected.

2. Effect of nitrogen application: Fertilizer application produced the same effect as that of variety Malan, when compared with no fertilizer. Application of fertilizer significantly increased grain yield per hectare as a result of increased production of dry matter, grain yield per plant, number of cobs per plot, number of cobs per plant, weight of cobs per plot, weight of grains per cob, and test weight of grains. Improvement in the grain yield per hectare of maize and other attributes of yield with the application of nitrogenous fertilizers may be attributed to universal

effect of nitrogen in increasing the corn yields, and findings of Vaidyanathan (1933), Stewart (1947), Sen and Kavitkar (1956), and those of many others may be cited in its support.

Increasing levels of nitrogen tended to increase grain yield per hectare. But application of nitrogen in doses higher than 67.23 kg. per hectare failed to bring about any marked improvement in grain yield over that of 67.23kg. per hectare, while doses lower than 67.23 kg. per hectare appreciably reduced grain yield per hectare; these consequences may be very aptly explained to have resulted because of inadequate supply of nitrogen in the ~~former~~ latter and supra-optimum supply of nitrogen in the ~~later~~ former. This affected the yield of grain per plant, number of cobs per plot, number of cobs per plant, weight of cobs per plot, and weight of grains per cob in the same manner. These finding are in confirmation with those of Raheja et al (1957) Varma & Sharma (1958) and Relwani (1962), who also reported greater response in grain yield with the application of 67.23 kg.N/Hectare (60 lb.N/acre).

A decreasing response in terms of grain yield per hectare with the increasing supplies of nitrogen was noted in this experiment and the same was also reported by Nelson (1956) , Goor (1957) and Fulton and Findlay (1960). However, application of the highest dose, i.e. 100.89 kg./hectare of nitrogen resulted in highest yield of grain per acre, which may be due to highest production of dry-matter per plant at all the stages of growth which tended to give this result. Highest test weight was also noted at this level. Nandpuri (1960) also recorded the highest grain yield with the highest level of nitrogen application (i.e. 120 lb.N/acre).

3. Effect of time of application of nitrogen: Application of nitrogen half at the time of sowing and half at the time of tasseling resulted in a significantly higher grain yield per hectare over its single application at the time of sowing. Although time of application of nitrogen did not affect the manifestation of various attributes of yield significantly but split application tended to cause a slight improvement in number of cobs per plot, weight of cobs per plot and test weight of grains; whereas single application brought about a minor improvement in yield of grain per plant, number of cobs per plant, and weight of grains per cob.

A significant increase in grain yield per hectare with the split application of nitrogen and reduction in the same with the single application of nitrogen appear to have been brought about by a continuous and gradual supply of nitrogen in the former case which ensured proper growth of the plants; and due to greater leaching losses in the latter which might have not permitted the fuller utilization of an applied dose of nitrogen.

Higher grain yields per acre were also obtained, by Gudkova (1939), Goor (1953), Laird and Lizarraga (1959) and many others, when nitrogen was applied in split doses but results of the present experiment do not find support from the results obtained by Kristianson (1941), Lanza (1959), Arnon (1962), etc.

B. STOVER YIELD PER HECTARE

Stover yield per hectare is the function of number of plants available for harvest and dry- matter and height per plant. Crop stand being more or less constant under each treatment marked variations in stover yield per hectare will have to be traced to variations in production of dry-matter and attainment of height by the plants. An examination of data in Table 14, reveals that plants of variety Malan not only attained greater height but also accumulated more dry-matter than those of variety Bassi selected, thus the former resulted in the production of higher per hectare yields of stover than that of the latter.

Application of nitrogen not only enhanced dry-matter production and height of the plants but also resulted in the production of more stover than the controls. Although application of increasing levels of nitrogen tended to bring about significant increases in height of the plant but did not influence the production of dry matter per plant. Application of the highest level of nitrogen, i.e. 100.89 kg./hectare produced in tallest plants which tended to produce largest dry-matter per plant and stover yield per hectare.

Like the highest level of nitrogen split application of nitrogen also gave tallest plants and highest yields of stover than its single application. Increasing levels of nitrogen even upto 100.89 kg./hectare and split application of nitrogen brought about favourable effects on the vegetative growth, which amounted to greater production of dry-matter and attainment of height by the plants and finally increased the stover yield. The findings are in confirmation to those obtained by Miller (1931) , Russell and Watson (1940) and Jordan et al (1950).

C. DRY-MATTER PRODUCTION AND NITROGEN CONTENT OF GROWING PLANT.

Dry-matter production per plant and per cent nitrogen in the plant followed the strikingly different pattern. The treatments which increased dry-matter production slightly lowered its nitrogen content. Growing of variety Malan increased dry-matter production per plant but reduced its nitrogen content. Application of fertilizer brought about a consistently greater production of dry-matter per plant and the production of dry-matter tended to increase with the increase in the application of nitrogen upto 100.89 kg./hectare. The effect of time of application of fertilizer were not in favour of any improvement in dry-matter production per plant or nitrogen content.

Reduction in the nitrogen content of plant are reflections of dilution of nitrogen due to greater production of dry-matter with a particular treatment. Greater reduction in nitrogen content of the plant with the application of 67.23 kg./hectare and no reduction or rather increase in nitrogen content of the plant with the application of 100.89 kg.N/hectare may be attributed to greater production of dry-matter in the former which diluted nitrogen content of the plant no further increase in dry-matter production in spite of the preponderance of nitrogen with latter.

Almost similar was the effect of time of application of fertilizer and that of growing of different varieties. Nitrogen content and dry-matter production increased with the split application of nitrogen and growing of variety Malan.

D. CRUDE AND TRUE PROTEIN CONTENTS OF GRAIN.

Grains of variety Malan contained slightly more of crude protein, while grains of variety Bassi selected contained more of true protein, but the differences were never significant. Application of nitrogen produced grains richer in crude and true proteins than those with no nitrogen. The plausible explanations for these increases may be, the greater availability of nitrogen to the growing plants which absorbed and assimilated more nitrogen during the growing period and later on resulted in a greater translocation of assimilated nitrogen from the vegetative parts to the seeds. Highest crude protein was analysed with the application of highest level of nitrogen (100.89 kg./hectare), whereas highest true protein content was recorded with 67.26 kg. nitrogen per hectare. Prince (1954), Zuber et al (1955) and Nandpuri (1960) also obtained increased protein content of grains with the increasing levels of nitrogen. Contrary to the observations of Selke (1938) and Russell and Watson (1939) late applications of nitrogen could not increase protein contents of the grains. It may be feasible to explain this on the guide lines that split applications brought of about significant increases in the grain yields thus had a dilution effect on the nitrogen (crude & true protein) content of grains.

E. *MINERAL CONTENT OF GRAINS*

Grains of variety Bassi selected contained significantly higher P & K but lower Ca than those of Malan. Greater P & K contents of grains of variety Bassi selected appear to be the reflection of reduced grain yield or greater capacity of this variety to absorb more of P & K. Slightly increased Ca content of grains of variety Malan, which contained more of crude protein might have been the result of greater absorption of Ca to neutralize the acids produced in the nitrogen metabolism of the plants.

Neither the amount nor the time of application of nitrogen had any significant effect on P, K & Ca contents of grain. However, split application of nitrogen slightly reduced K & Ca but high phosphorus contents of grains.

Application of nitrogen irrespective of levels tended to give grains richer in P, K & Ca contents than controls. Application of 67.23 kg. N/hectare , which gave greater yield responses and resulted in a higher per cent of nitrogen in plants and true protein in grains also gave the highest per cent of phosphorus in grains; whereas application of the highest level of nitrogen not only gave greater drymatter production, grain and stover yield per hectare and test weight of grain but also tended to produce grains containing highest per cent of Ca. Single application of nitrogen, all at the time of sowing, gave lower P but higher K & Ca contents of the grains than the split application.

SUMMARY

A field experiment, entitled 'Comparative performance of two varieties of maize under single versus split application of different levels of nitrogen', was planned out at the college farm in the Kharif season of 1962-'63. Main results obtained due to this experiment are summarised below:

1. Grain yield per hectare of variety Malan was 47.0 per cent higher than that of variety Bassi selected. The higher grain yield under variety Malan was associated with greater production of grain per plant, number of cobs per plot, weight of cobs per plot, weight of grains per cob, test weight of grain and stover yield per hectare.

2. Variety Bassi selected matured 20 days earlier than variety Malan.

3. Application of nitrogen, irrespective of levels, tended to produce a rank growth of plants and resulted in greater yields of grain per hectare, yield of grain per plant, number of cobs per plot, number of cobs per plant, weight of cobs per plot, weight of cobs per plot, weight of grains per cob, test weight of grains, and stover yield per hectare.

4. Application of 67.23 kg. nitrogen per hectare had an over all better effect on grain and stover yield per hectare as also on various other attributes of grain yield and when compared with no nitrogen or with 33.63 kg.N/hectare, increased the yield of grain by 37.41 and 23.25 per

cent and stover yield by 29.5 and 16.2 per cent. Although grain and stover yield tended to increase with increase in the level of nitrogen but there was no significant increase in yield of grain and stover with the application of 100.89 kg. nitrogen over that of 67.23 kg. nitrogen per hectare.

5. Application of nitrogen half at sowing and half at tasseling produced most favourable effects on grain and stover yield and their various attributes.

6. Quality of grains of variety Malan was better than that of variety Bassi selected as far as crude and true proteins contents are concerned. The same effects on grain quality were obtained with the application of nitrogen, increasing levels of nitrogen and under split applications. But seeds of variety Bassi selected were rich in P & K contents.

7. Growing of variety Malan with the application of 67.23 kg. and 100.89 kg. nitrogen per hectare, supplied half at sowing and the other half at tasseling produced maximum yields, while variety Bassi selected did not respond to levels of nitrogen beyond 67.23 kg. per hectare.

C O N C L U S I O N.

The results of one year's experimentation reveal the superiority of variety Malan over variety Bassi selected. Growing of variety Malan with 60 lb. nitrogen per hectare, applied half at sowing and half at tasseling may be recommended to realize the object of very high yields of maize in this region.

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APPENDIX TABLES

TABLE I

DRY-MATTER PRODUCTION PER PLANT IN GM.

ANALYSIS OF VARIANCE

Variation due to	d.f.	21 M.S.S.	21 Variance ratio	42 M.S.S.	42 Variance ratio	63 M.S.S.	63 Variance ratio	84 M.S.S.	84 Variance ratio
Replications	2	0.68	18.70*	155.35	1.16	771.39	1.78	209.62	0.05
Control vs. Nitrogen	1	0.01	0.29	161.78	1.21	3875.58	8.96*	19902.63	4.81*
Levels of Nitrogen	2	0.01	0.18	91.69	0.69	2603.67	6.02*	1819.52	0.44
Time of fertilization	1	0.001	0.05	186.96	1.40	75.55	0.18	326.65	0.08
Varieties	1	0.08	2.23	44.26	0.33	397.73	0.92	50269.32	12.15*
Interaction									
(NT)	2	0.19	6.35*	227.83	1.70	81.83	0.19	13945.18	3.37*
(NV)	3	0.15	4.12*	46.76	0.35	239.94	0.56	3906.16	0.94
(TV)	1	0.06	1.62	159.01	1.19	142.60	0.33	1607.48	0.39
(NTV)	2	0.31	8.56*	90.47	0.68	551.33	1.27	9083.28	2.20
Error	32	0.04	-	133.71	-	432.62	-	4136.81	-

Age in days: 21, 42, 63, 84

* Significant at 5%

TABLE II

AVERAGE HEIGHT OF THE PLANT IN CM.

ANALYSIS OF VARIANCE

Variation due to	d.f.	Age in days: 21		35		42		49		56		63	
		M.S.S.	Variance ratio	M.S.S.	Variance ratio	M.S.S.	Variance ratio	M.S.S.	Variance ratio	M.S.S.	Variance ratio	M.S.S.	Var
Replications	2	2.08	0.37	173.15	5.25*	2529.84	11.13*	539.23	3.54*	370.90	1.96	472.13	
Control vs. Nitrogen	1	0.10	0.02	118.01	3.58	657.07	2.89	470.17	3.09	868.28	4.59*	2415.72	
Levels of Nitrogen	2	3.50	0.63	214.11	6.49*	679.48	2.99	341.63	2.24	138.06	0.73	798.16	
Time of fertilization	1	9.61	1.73	1.28	0.04	110.25	0.48	425.73	2.80	53.78	0.28	49.79	
Varieties	1	8.25	1.49	313.35	9.50*	2932.81	12.90*	11059.54	72.66*	18486.75	97.79*	6258.24	
Interactions													
(NT)	2	26.49	4.77*	6.12	0.19	213.12	0.94	186.40	1.23	44.46	0.24	20.68	
(NV)	3	1.63	0.29	54.72	1.66	222.16	0.98	53.98	0.35	103.08	0.55	3442.49	
(TV)	1	0.34	0.06	16.29	0.49	124.69	0.55	53.29	0.35	255.99	1.35	15.73	
(NTV)	2	12.90	2.32	25.04	0.76	108.11	0.48	1.08	0.01	36.21	0.19	11.13	
Error	32	5.55	-	32.99	-	227.39	-	152.20	-	189.04	-	204.87	

* Significant at 5%

TABLE III

NITROGEN PERCENTAGE IN PLANTS

ANALYSIS OF VARIANCE

Variation due to	d.f.	Age in days							
		21		42		63		84	
		M.S.S.	Variance ratio	M.S.S.	Variance ratio	M.S.S.	Variance ratio	M.S.S.	Variance ratio
Replications	2	0.890	4.985*	0.633	8.054*	0.329	4.842*	0.146	9.900*
Control vs. Nitrogen	1	0.021	0.012	0.001	0.012	0.660	10.007*	0.001	0.004
Levels of Nitrogen	2	0.301	0.686	0.249	0.171	0.226	3.434*	0.062	4.226*
Time of fertilization	1	0.176	0.981	0.022	0.286	0.009	0.132	0.075	5.040*
Varieties	1	0.014	0.081	0.172	2.191	0.277	4.195*	0.012	0.780
Interactions									
(NT)	2	0.107	0.600	0.079	1.012	0.037	0.564	0.066	4.430*
(NV)	3	0.017	0.010	0.037	0.473	0.246	3.737	0.006	0.370
(TV)	1	0.058	0.032	0.261	3.326	0.037	0.564	0.047	3.210
(NTV)	2	0.012	0.064	0.103	1.316	0.012	0.173	0.023	1.520
Error	32	0.179	-	0.079	-	0.066	-	0.015	-

* Significant at 5%

TABLE IV

GRAIN YIELD AND ATTRIBUTES OF GRAIN YIELD

ANALYSIS OF VARIANCE

Variation due to	d.f.	Yield/plot in kg.		Yield/plant in gm.		Crop stand			
		M.S.S.	Variance ratio	M.S.S.	Variance ratio	M.S.S.	Variance ratio	M.S.S.	Variance ratio
Replication	2	3.15	1.50	614.78	3.26	1370.31	5.95*		
Control vs. Nitrogen	1	68.04	32.40*	2007.04	10.64*	697.84	3.01		
Levels of Nitrogen	2	18.33	8.73*	147.63	0.78	209.53	0.90		
Time of fertilization	1	25.45	12.12*	239.22	1.27	0.25	0.01		
Varieties	1	429.01	204.29*	267.08	14.15*	638.02	2.75		
Interaction									
(NT)	2	4.23	2.01	199.52	1.06	48.25	0.21		
(NV)	3	11.53	5.49*	319.88	1.70	145.95	0.63		
(TV)	1	21.60	10.29*	68.34	0.36	342.25	1.48		
(NTV)	2	3.03	1.44	50.54	0.27	122.17	0.53		
Error	32	2.10	-	188.71	-	232.04	-		

* Significant at 5%

TABLE V

COB YIELD AND ATTRIBUTES OF COB YIELD

ANALYSIS OF VARIANCE

Variation due to	d.f.	Number of cobs per plot: In first picking M.S.S.	Variance ratio.	Number of cobs per plot: In second picking M.S.S.	Variance ratio.	Number of cobs per plot: Total M.S.S.	Variance ratio	No. of cobs per plant. M.S.S.	Variance ratio.	Weight of cobs per plot. M.S.S.	Variance ratio.
Replication	2	3791.32	5.74*	1160.42	6.00*	1195.75	1.90	0.0208		2.45	0.84
Control vs. Nitrogen	1	4268.45	6.46*	50.17	0.26	5100.34	8.10*	0.0011		152.01	52.07*
Levels of Nitrogen	2	1190.86	1.80	63.19	0.33	1665.03	2.64	0.0003		30.07	10.30
Time of fertilization	1	367. 36	0.56	981.78	5.08*	2550.25	4.05	0.0003		3.24	1.11
Varieties	1	41184.08	62.31*	1862.52	9.63*	25715.02	40.83*	0.0075		394.17	135.03*
Interaction											
(NT)	2	251.19	0.38	185.03	0.96	794.08	1.26	0.0020		1.93	0.66
(NV)	3	196.14	0.30	22.91	0.12	278.35	0.44	0.0036		17.19	5.89*
(TV)	1	146.25	0.22	373.78	1.93	46.69	0.07	0.0004		9.62	3.29
(NTV)	2	65.08	0.10	666.54	3.45*	344.19	0.55	0.0061		3.27	1.12
Error	32	660.92	-	193.40	-	629.84	-	0.1189		2.92	-

* Significant at 5%

TABLE VI

STOVER YIELD AND ATTRIBUTES OF STOVER YIELD

ANALYSIS OF VARIANCE

Variation due to	d.f.	Number of plants per plot.		Dry-matter per plant at harvest in gm.		Height of the plant at 63 days in cm.		Stover yield per plot in kg.	
		M.S.S.	Variance ratio	M.S.S.	Variance ratio	M.S.S.	Variance ratio	M.S.S.	Variance ratio.
Replications	2	1370.31	5.91*	209.62	0.05	472.13	2.31	47.02	2.81
Control vs. Nitrogen	1	697.84	3.01	19902.63	4.81*	2415.72	11.79*	333.06	19.89*
Levels of Nitrogen	2	209.53	0.90	1819.52	0.44	798.16	3.90*	112.58	6.72*
Time of fertilization	1	0.25	0.01	326.65	0.08	45.79	0.22	220.03	13.14*
Varieties	1	638.02	2.75	50269.32	12.15*	6258.24	30.55*	638.02	38.09*
Interaction									
(NT)	2	48.25	0.21	13945.18	3.37*	20.68	0.10	4.30	0.26
(NV)	3	145.95	0.63	3906.16	0.94	3442.49	16.80*	5.24	0.31
(TV)	1	342.25	1.48	1607.48	0.39	15.73	0.08	3.34	0.20
(NTV)	2	122.17	0.53	9083.28	2.20	11.13	0.05	9.17	0.55
Error	32	232.04	-	4136.81	-	204.87	-	16.75	-

Error * Significant at 5%

TABLE VII

QUALITY OF GRAIN

ANALYSIS OF VARIANCE

Variation due to	d.f.	Crude protein percentage.		Phosphorus percentage		Potassium percentage		Calcium. percentage.	
		M.S.S.	Variance ratio	M.S.S.	Variance ratio	M.S.S.	Variance ratio	M.S.S.	Variance ratio
Replications	2	0.91	0.681	0.000730	2.470	0.00052	0.673	0.00866	1.848
Control vs. Nitrogen	1	1.34	1.004	0.000265	0.896	0.00032	0.423	0.00218	0.465
Levels of Nitrogen	2	5.69	4.250*	0.000509	1.724	-	-	0.00541	1.155
Time of fertilization	1	2.12	1.584	0.000003	0.009	0.00004	0.047	0.00028	0.059
Varieties	1	0.14	0.105	0.001338	4.524*	0.00691	9.016*	0.01763	3.763
Interaction									
(NT)	2	0.05	0.039	0.000113	0.383	0.00019	0.250	0.00755	1.610
(NV)	3	3.34	2.498	0.000547	1.851	0.00129	1.691	0.00832	1.776
(TV)	1	0.43	0.322	0.000841	2.844	0.00068	0.882	0.00188	0.401
(NTV)	2	0.73	0.542	0.000167	0.565	0.00174	2.275	0.01008	2.151
Error	32	1.34	-	0.000296	-	0.00077	-	0.00469	-

* Significant at 5%

TABLE VIII

TREATMENTWISE TRUE PROTEIN CONTENT OF GRAINS

Treatments	True protein (%)
$N_0 T_1 V_M$	5.775
$N_0 T_1 V_B$	3.175
$N_0 T_2 V_M$	5.250
$N_0 T_2 V_B$	5.950
$N_{30} T_1 V_M$	6.670
$N_{30} T_1 V_B$	6.670
$N_{30} T_2 V_M$	3.875
$N_{30} T_2 V_B$	6.495
$N_{60} T_1 V_M$	6.845
$N_{60} T_1 V_B$	8.575
$N_{60} T_2 V_M$	6.125
$N_{60} T_2 V_B$	3.525
$N_{90} T_1 V_M$	6.495
$N_{90} T_1 V_B$	4.050
$N_{90} T_2 V_M$	5.425
$N_{90} T_2 V_B$	8.575

TABLE IX

SCHEDULE OF HARVEST

Observation	Varieties			
	Bassi selected		Malan	
	Date	Age in days	Date	Age in days
First picking of cobs.	26.9.'62	85	17.10.'62	106
Second picking of cobs.	4.10.62	93	24.10.62	113
Harvesting of stover.	8.10.62	97	28.10.62	117

TABLE X

DETAILS OF STATISTICAL PROCEDURE FOLLOWED

Character ....

No. of observation ....

Date ....No. of days after sowing .....

Table (i) Treatment vs. replication.

Treatment	Rep. I Plot No.	Rep. I Reading	Rep. II Plot No.	Rep. II Reading	Rep. III Plot No.	Rep. III Reading	TOTAL
$N_0T_1V_M$	14		18		39		
$N_0T_1V_B$	5		22		43		
$N_0T_2V_M$	10		30		33		
$N_0T_2V_B$	8		24		48		
$N_{30}T_1V_M$	7		25		45		
$N_{30}T_1V_B$	6		20		40		
$N_{30}T_2V_M$	1		26		46		
$N_{30}T_2V_B$	11		29		38		
$N_{60}T_1V_M$	13		31		34		
$N_{60}T_1V_B$	3		27		44		
$N_{60}T_2V_M$	9		19		37		
$N_{60}T_2V_B$	16		28		42		
$N_{90}T_1V_M$	15		23		41		
$N_{90}T_1V_B$	12		17		47		
$N_{90}T_2V_M$	2		21		36		
$N_{90}T_2V_B$	4		32		35		
Total							

Table (ii) <u>Nitrogen vs. varieties.</u>

Treatments	N_0	N_{30}	N_{60}	N_{90}	TOTAL
V_M					
V_B					
TOTAL					

Table (iii) <u>Control vs. nitrogen.</u>

(ΣN_0)	$(\Sigma N_{30} + \Sigma N_{60} + \Sigma N_{90})$	TOTAL

Table (iv) <u>Nitrogen vs. time of fertilization.</u>

Treatments	N_{30}	N_{60}	N_{90}	TOTAL
T_1				
T_2				
TOTAL				

Table (v) <u>Varieties vs. time of fertilization.</u>

Treatments	V_M'	V_B'	TOTAL
T_1			
T_2			
TOTAL			

CALCULATIONS:

I. Sum of squares:

1. Correction factor (A) from Table (i) = C.F. (A) =

$$= \frac{(\text{Grand total})^2}{48}$$

2. S.S. due to total from Table (i) = S.S.(Total) =

= S.S. of all readings from 1st to 48th −C.F(A)

3. S.S. due to replications from Table (i) =S.S.(Rep.)=

$$= \frac{(R_1)^2 + (R_2)^2 + (R_3)^2}{16} - \text{C.F.(A)}$$

4. S.S. due to treatments from Table (i) = S.S.(Treat.)=

$$= \frac{(N_0V_M)^2}{6} + \frac{(N_0V_B)^2}{6} +$$

$$\frac{(N_{30}T_1V_M)^2 + \dots + (N_{90}T_1V_B)^2}{3} - \text{C.F.(A)}$$

5. S.S. due to levels of nitrogen from Table (ii)= S.S.(N)=

$$\frac{(N_0)^2 + (N_{30})^2 + (N_{60})^2 + (N_{90})^2}{12} - \text{C.F.(A)}$$

6. S.S. due to varieties from Table (ii)=S.S.(V)=

$$= \frac{(V_M)^2 + (V_B)^2}{24} - \text{C.F.(A)}$$

7. S.S. due to interaction (NV) from Table (ii) =S.S.(NV)=

$$= \frac{N_0V_M^2 + N_0V_B^2 + \dots + N_{90}V_M^2 + N_{90}V_B^2}{6} -$$

$$(\text{C.F.(A)} + \text{S.S.(N)} + \text{S.S.(V)})$$

8. S.S. due to control vs. nitrogen from Table (iii) =

$$= \frac{(N_0)^2}{12} + \frac{(N_{30} + N_{60} + N_{90})^2}{36} - C.F.(A)$$

9. Correction factor (B) from Table (iv) or (v) = C.F.(B) =

$$= \frac{(\text{Grand total})^2}{36}$$

10. S.S. due to nitrogen from Table (iv) = S.S.(N') =

$$= \frac{(N_{30})^2 + (N_{60})^2 + (N_{90})^2}{12} - C.F.(B)$$

11. S.S. due to time of fertilization from Table (iv) or (v) =

$$= S.S.(T) = \frac{(T_1)^2 + (T_2)^2}{18} - C.F.(B)$$

12. S.S. due to interaction (NT) from Table (iv) = S.S.(NT) =

$$= \frac{N_{30}T_1^2 + N_{30}T_2^2 + \ldots + N_{90}T_1^2 + N_{90}T_2^2}{6} -$$

$$(C.F.(B) + S.S.(N') + S.S.(T)).$$

13. S.S. due to varieties from Table (v) = S.S.(V') =

$$= \frac{(V_M')^2 + (V_B')^2}{18} - C.F.(B)$$

14. S.S. due to interaction (TV) from Table (v) = S.S.(TV) =

$$= \frac{T_1V_M'^2 + T_1V_B'^2 + T_2V_M'^2 + T_2V_B'^2}{9} -$$

$$(C.F.(B) + S.S.(V') + S.S.(T))$$

15. S.S. due to second order inter action (NTV) = S.S.(NTV) =

$$= S.S.(Treat.) - \left\{ \begin{array}{l} S.S.(N') + S.S.(V) + S.S.(T) + \\ S.S.(NV) + S.S.(NT) + S.S.(TV) + \\ S.S.\ control\ vs.\ nitrogen \end{array} \right\}$$

16. S.S. due to error = S.S. (Error) =

$$= S.S.(Total - \{ S.S.(Treat.) + S.S.(Rep.)\}$$

II. <u>Standard error of Means</u> = (S.Em.±):

1. Control vs. treatment = $\sqrt{\frac{\text{Error M.S.S.}}{24}}$

2. Levels of nitrogen = $\sqrt{\frac{\text{Error M.S.S.}}{12}}$

3. Time of fertilization = $\sqrt{\frac{\text{Error M.S.S.}}{18}}$

4. Varieties = $\sqrt{\frac{\text{Error M.S.S.}}{24}}$

5. Interaction (NV) = $\sqrt{\frac{\text{Error M.S.S.}}{6}}$

6. Interaction (TV) = $\sqrt{\frac{\text{Error M.S.S.}}{9}}$

7. Interaction (NT) = $\sqrt{\frac{\text{Error M.S.S.}}{6}}$

8. Interaction (NTV) = $\sqrt{\frac{\text{Error M.S.S.}}{3}}$

III. <u>Least significant difference</u> = (L.S.D.) =

(for 32 d.f. $t_{0.975} = 2.038$)

L.S.D. = S.Em. X $t_{0.975}$ X $\sqrt{2}$

= S.E.m. X 2.038 X 1.414

= S.Em. X 2.882.

Table (vi) Analysis of Variance.

Variation due to	d.f.	S.S.	M.S.S.	Variance ratio	S.Em. ±	L.S.D. (P=0.05)
Replications(R)	2					
Control vs. nitrogen	1					
Levels of nitrogen (N)	2					
Time of fertilization (T)	1					
Varieties	1					
Interactions						
(NT)	2					
(NV)	3					
(TV)	1					
(NTV)	2					
Error	32					
TOTAL	47					